DrillWell

DRILLING AND WELL CENTRE
FOR IMPROVED RECOVERY

ANNUAL REPORT 2017

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 the status as a 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 four industrial partners; Statoil, Wintershall, ConocoPhillips and Aker BP. DrillWell is an industry-driven collaboration and innovation environment. The industrial partners prioritize and direct the R&D effort towards particular challenges. The Centre is a living proof of Stavanger and Trondheim joining forces together with the international oil and gas industry.

The annual budget for 2017 was approximately NOK 48 million. NOK 10 million was granted from the Research Council of Norway, and the industry partners contributed with a total of NOK 24 million. In addition, NOK 14 million was funded by the Research Council for three PETROMAKS2 projects together with industry funding from DrillWell. One international partnership project (INTPART) with US partners in Texas was also funded by the Research Council.

A total of fifty researchers, ten professors and associate professors, six PhD candidates, three Post Docs and twelve graduated MSc students have contributed to the Centre activities in 2017. This has resulted in 18 journal papers and 24 additional publications plus several keynote speeches and popular publications. Prototype software for drilling process optimization has been tested by participating oil companies. The Centre organizes one large seminar annually and distributes the DrillWell Newsletter quarterly.

CONTENT

DrillWell 2017	4
People in DrillWell	6
Scientific Advisory Committee	7
DrillWell organisation	8
Technologies are maturing	10
Programme 1: Safe and efficient drilling operations for cost reduction	12
Programme 3: Well solutions for improved recovery	18
PhD students	24
Post docs	25
International collaboration	27
Communication and dissemination activities	28
New artificial rock for plug and abandonment	30
The annual DrillWell seminar	32
DrillWell Researchers	35
DrillWell Publications	36

DRILLWELL 2017

As DrillWell is in the middle of phase two, the main emphasis is on maturing results and producing deliverables. One example is the application of software developed in our drilling process optimization project, which was used by Sekal while assisting Statoil for automated drilling control on the semi-submersible rig Songa Enabler.

Prototype software for drilling process optimization has also been installed at oil company offices for testing and application, and there is dialogue with service companies for the implementation and commercialization of useful models and knowledge.

The R&D work within our four focus areas; Drilling Process Optimisation, Well Control, Well Integrity and Plugging and Abandonment of wells, is aiming for improved safety and cost reduction, thus contributing to economic development of new prospects and to keep mature fields in operation.

Our main results are presented at international conferences and in journal papers. In phase two we have succeeded in increasing the number of journal papers. Six PhD students and four post docs are engaged, and twelve master students contributed in 2017 through their thesis work.

During the autumn a full-scale experiment was planned and executed to study cement placement in wells with washout, building on laboratory experiments performed earlier and supported by computer modelling of the displacement process.

Competence and technology developed by DrillWell has been essential for establishing spin-off projects within geo-steering, real-time drilling data acquisition and processing, drilling geo-thermal wells, and multi-phase phenomena in complex fluids, the last one being part of the PIRE programme (Partnership for International Research and Education).

Our international cooperation includes eight universities including four in Texas, two in Canada and two in France. A one-day workshop within Digitalisation was arranged in Houston with the INTPART NorTex Data Science Cluster project.

The annual seminar arranged at Sola had broad participation from oil companies, service companies and researchers, giving a good setting for presenting and discussing recent results. Presentations included front end technology from the service companies and challenging operations from the oil companies as well as high quality R&D results. This mixture turned out to be very successful.

Including three Petromaks2 funded spin-off projects, the centre budget is around NOK 45 million per year in the second phase which will last until summer 2019. Discussions have started with the participating oil companies regarding a phase 3 with industry funding from a larger group of oil companies and with involvement of service companies.

Sigmund Stokka

Sigmund Stokka
DrillWell Manager, IRIS

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 percent of the field development cost.

DrillWell
DRILLING AND WELL CENTRE FOR IMPROVED RECOVERY

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IRIS

SCIENTIFIC ADVISORY COMMITTEE

In 2015 DrillWell established a Scientific Advisory Committee (SAC). The Committee comprises 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.*

Representatives from SAC attended the DrillWell seminar in September 2017 and contributed with their knowledge and experience during the seminar. Dr. John L. Thorogood, drilling engineering advisor at Drilling Global Consultant LLP and member of the SAC commented on the seminar. - It was an excellent set of presentations by DrillWell scientists and industrial end users. The work is truly leading edge both on the automation side and on the P&A. A well-organized seminar and a valuable showcase for the DrillWell activities. More effort should be devoted to getting attendance from the other Norwegian operators and also from the UK, the Oil and Gas Authority and also the Oil and Gas Technology Centre. These people really do need to know of the exciting stuff going on in Norway, Dr. Thorogood concluded.

After the seminar, SAC and the DrillWell management team had a separate meeting in Stavanger. Scientific progress, deliverables from DrillWell and scientific production were on the agenda. As usual, SAC gave valuable advice regarding priorities and direction for DrillWell.

The following international experts are members of SAC:

JOHN THOROGOOD
DRILLING ENGINEERING ADVISOR AT DRILLING GLOBAL CONSULTANT LLP

Following 34 years with BP, now an independent consultant with 45 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
PRINCIPAL PROGRAMME MANAGER, DANISH HYDROCARBON RESEARCH & TECHNOLOGY CENTRE, DTU

Started her engineering career with Maersk Oil and later DONG E&P holding various positions related to Drilling and Production Technology over a period of 25 years. In April 2015, she joined the research centre DHTRC at DTU. The work involves building up a 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. The overarching purpose is to identify new technological and conceptual solutions that boost oil and gas extraction in the Danish section of the North Sea.

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

Has held faculty positions at the New Mexico Institute of Mining and Technology and the AGH University of Science and Technology in Krakow, Poland. He is a UN expert in drilling engineering and has 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

DrillWell Board

Technical Committee

Scientific Advisory Committee

Centre Manager & Management Group

PROGRAMME 1

Safe and Efficient Drilling Operations for Cost Reduction

PROGRAMME 2

Geosteering and Drilling Solutions for Improved Recovery

PROGRAMME 3

Well Solutions for Improved Recovery

Reference group P1

Completed in 2016

Reference group P3

INDUSTRY PARTNER PERSPECTIVES

Fredrik Varpe Statoil

The results from the DrillWell SFI have contributed to improved drilling process quality. Prototype tools for assisting the operational drilling process control, developed during the first phase of the programme, have been tested and implemented in existing systems used by the industry partners. Through industrialization and commercialization of the applications, the results of the SFI work is becoming visible with several examples of high value creation for DrillWell members. We are now well into phase 2 of the programme and many of our PhD candidates are finalizing their work. It is important that we ensure that the scientific communities of DrillWell deliver on their academical objectives, remain strong and able to serve the Norwegian oil and gas industry beyond the duration of the programme.

Rune Woie ConocoPhillips

The DrillWell programmes are moving ahead and several of the activities are moving into validation testing to make sure that the new developments give the added value that is anticipated and prognosed. Validation has high priority also to test theory versus reality. This is a challenging task and also assumes available resources from both the researchers and the operator. From the operator point of view it is essential that value is documented throughout the project phase not only waiting for the final results. This will also help to guide the project in the right direction. New technologies and methods that simplify operations are needed to keep continued improved HSE, risks, efficiency and cost.

Per Seim Aker BP

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. Important contributions to the understanding of well behaviour and mapping of data streams have been made and will enable and facilitate the change to a digitalized drilling world. Technology improvements and understanding of the processes involved in well construction and control are important building blocks and important contributions to the advancement of our industry. We are impressed by the work done in the different projects and are eager to use the results in our daily operations.

Torgeir Larsen Wintershall

The R&D programme 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 AkerBP wintershall

Foto: Yngve Olsen Sæbbe

Songa Enabler at
Olavsvern in Tromsø.

Technologies are maturing

In 2017 DrillTronics® was successfully installed on the mobile drilling rig Songa Enabler, which offers enormous market opportunities for the automation system. The Drilling Data Hub is setting a new digital standard offering oil & gas companies reliable access to real-time drilling data. Finally, the Ullrigg Drilling and Well Centre has proved to be a full-scale test facility for P&A experiments that closely replicate reality.

PROMISING MARKET FOR DRILLTRONICS

Research Director at IRIS, Helga Gjeraldstveit, explains that DrillWell has made a significant contribution to the adaption of DrillTronics, enabling the system to be used also on semisubmersible rigs like Songa Enabler.

-The system's unique and advanced model for transient torque and drag has been developed by DrillWell and will be decisive when drilling more deviated wells in 2018, Gjeraldstveit points out.

This year DrillTronics was installed on Songa Enabler, and when the exploration campaign in the Barents Sea began, Songa Enabler was the world's first semisubmersible rig to use an automated data collection system. On Songa Enabler DrillTronics software automates drilling process control and enables drillers to optimize and enhance the safety of their drilling operations. It helps drillers avoid critical situations that might lead to significant economic losses. This summer alone, Statoil/Songa Enabler is believed to have saved in the order of 100 million NOK using DrillTronics drilling two well sections in the Barents Sea, primarily because DrillTronics helped avoid expensive sidetracks.

-It is important that automation systems like DrillTronics are also utilized on mobile rigs, where safety and efficiency are crucial parameters like on all other rigs. This widens the market potential for this product, since the mobile rigs drill many more wells than platform based rigs, Gjeraldstveit concludes.

OPTIMIZE DRILLING OPERATIONS

DrillWell's chairman, Fredrik Varpe from Statoil says:

- 2017 has been a break-through-year for automated drilling in Statoil. We have improved our infrastructure with Deal from MHWirth, Novos from National Oil Well and Wired pipe. This gives us the opportunity to use many new digital and automated applications that allow us to monitor and control drilling in real-time. We can now monitor and interpret real-time data from both rigs and down-hole, and detect incidents and optimize drilling parameters in real-time.

The next step for Statoil will be to open these digital applications to give suppliers access to Statoil's real-time data. This again will develop solutions where Statoil and suppliers jointly can optimize drilling operations. In the future Varpe sees data-driven methods, automated drilling and real-time updates of reservoir models to accommodate optimal reservoir navigation and maybe even higher precision in planning and real-time predictions through digital twins.

"PLUG & PLAY" WITH DRILLING DATA HUB

Drilling Data Hub is a prototype for a new data hub that acquires and processes real-time data from drilling operations. On Tuesday October 3rd the DDHub was demonstrated in front of an enthusiastic industry audience in Stavanger and close to 30 persons from the industry attended the two demonstrations. The presenters emphasized the need for reliable access to real-time data, and to accomplish that a complex application – the Drilling Data Hub – is needed. Further, they showed how real-time data can be acquired and aggregated based on semantical descriptions.

D&W Lead Engineer Digitalization at DrillWell partner Aker BP, Alf Sævland, believes strongly in the Drilling Data Hub and says:

- Drilling Data Hub is an important R&D and standardization tool for Aker BP. It is our vision that suppliers, drilling equipment, software and algorithms must be operative without costly configuration. Predominantly it must be «Plug and Play» and the Drilling Data Hub, with its semantic data model is a prerequisite to make this happen, and we have worked with our strategic partners within rig and drilling service to establish this. If other oil & gas operators in Norway join us and implement Drilling Data Hub, it will be a milestone in our efforts to establish a standard for digital services that will offer the Norwegian Continental Shelf a competitive advantage. DrillWell plays a very important part in the establishment of this new standard.

It is our vision that suppliers, drilling equipment, software and algorithms must be operative without costly configuration. Predominantly it must be «Plug and Play»

The project will be continued through DrillWell and the Demo2000 project Demonstrations of Drilling Data Hub, that includes operators and oil service companies. The demonstration was the first important milestone for the Drilling Data Hub and the next milestone will be in 2018, where a full set of semantical descriptions will be ready and demonstrated.

FULL SCALE CEMENTING RESEARCH

The Ullrigg Drilling and Well Centre in Stavanger is a significant factor for the DrillWell research. This year the test facility has completed several full-scale experiments within P&A, showing that the experiments are as close to reality as ever. At the end of the year four annulus test assemblies were constructed and tested, three of them with a model hole enlargement. The experiments were part of the knowledge building DrillWell KPN project, Cementing irregular wellbore geometries.

The assemblies were cemented in November 2017, assisted by Halliburton who designed and delivered fluids and cementing personnel. The purpose of the experiments was to investigate how the hole enlargement and inner-string eccentricity affects cement placement in near horizontal annuli. Measurements recorded during displacement were compared with CFD simulation results, and the state of the hardened cement was investigated by pressure and leakage tests.

Fredrik Varpe,
Chairman of the Board
Statoil

Helga Gjeraldstveit
Memeber of the management team
IRIS

Jan Einar Gravdal,
Programme Manager

PROGRAMME 1:

Safe and efficient drilling operations for cost reduction

DrillWell's programme on safe and efficient drilling operations for cost reduction is extremely relevant these days by targeting sensors, distribution of drilling data and data analytics. All are important elements to enable a digital switchover for the drilling industry.

- We are very pleased to see that our project objectives and deliverables are so aligned with the industry's needs within drilling & well.

This research programme aims to deliver technology to improve drilling safety and performance as well as avoiding drilling related problems. The programme has, since its start in 2011, had a broad variation of research topics, from new sensor technologies, to acquisition and distribution of real-time drilling data, to advanced analytics software. In 2016, the transient cuttings transport model, delivered by this programme, contributed to cost savings in the order of hundreds of millions NOK. In 2017 a new drill string vibration model has been developed with the potential to contribute with savings of the same order. The benefit by using these models is both improved performance during drilling, and to avoid expensive sidetracks.

To prepare for drilling automation, the ability of computer systems or software to exchange and make use of information (interoperability) is a key element. In 2017, DrillWell has addressed this through the DDHub (Drilling Data Hub) activity where we develop a prototype drilling data acquisition system. This work has drawn attention internationally, and we hope that this can be yet another deliverable that is being adopted by the industry. The DDHub activity is part of the project Drilling Process Optimization.

Three projects have been run within this programme in 2017:

- Drilling Process Optimization
  (project manager: Eric Cayeux)
- Well Control Simulator
  (project manager: Knut S. Bjørkevoll)
- Pressure Ahead - Pressure Prediction Ahead of Bit With Uncertainties (project manager: Ane Lothe)

Meet Dalila de Sousa Gomes, researcher at UiS

- Most of my spare time I really enjoy staying home relaxing, taking care of my pets, watching movies and series or reading. But I also like travelling from time to time, see new places and see beautiful landscapes. Norway is amazing for that and I love hiking in the beautiful mountains around here.

PROGRAMME 1

Name: Dalila de Sousa Gomes

Age: 33

Nationality: Brazil

Education: BSc in Chemical Engineering, MSc in Mechanical Engineering. PhD student at University of Stavanger, Institute of Petroleum technology.

Department: Petroleum engineering - University of Stavanger

Hi Dalila, what are you working on right now?

I work on kick tolerance simulation / gas kick migration. During the last semester, I have worked on the improvement of a numerical code for gas kick simulation in water-based mud. The improvement comprised the implementation of stochastic modelling which is a tool to incorporate uncertainty and give a better overview of the process. There is also an innovative aspect, since the stochastic methodology used with a transient flow model is something new. This code was used to perform kick tolerance studies.

Why do you find this interesting?

It is inspiring to work with an innovative project. This project is also multidisciplinary, which makes it very interesting. It involves statistics, programming, petroleum engineering and chemistry, which totally fits my background both academically and with respect to working experience. It is gratifying to put my skills in practice. I would also like to add that the environment at UiS is very nice and the other people involved in the project are very competent and collaborative. I am also glad to be working with a project which has the potential of solving some technical issues currently faced by the industry.

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

Yes, a lot. I like being in contact with the industry and align my research with its needs. This way I know that my work will have practical applications. Besides, I believe that having people with different backgrounds enriches the project and that great scientific advances can be achieved when academia and industry work together.

Do you see yourself working within oil and gas in ten years' time? If yes, doing what?

I definitely see myself in the oil and gas field. Regarding the activity I will be performing in the future, I am not sure now. I really like working with this subject and I love research. However, I prefer to be open to other possibilities suited to my profile and evaluate the opportunities as they appear in my career.

Eric Cayeux
Chief Scientist at IRIS
and project manager
of Drilling Process
Optimization

PROGRAMME 1

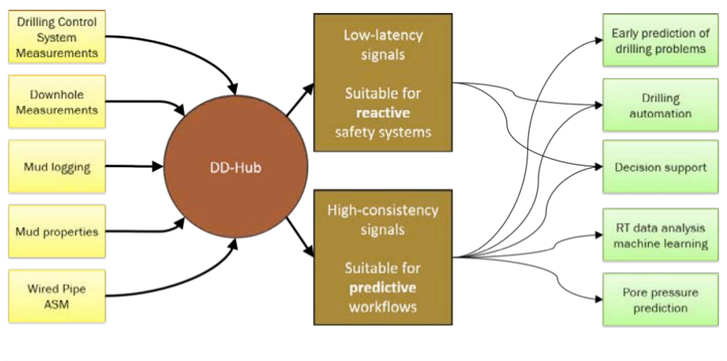
Drilling process optimization

Drilling is a process that involves several companies, including the drilling contractor, downhole service, data logging, drilling fluid engineering and cementing companies. Each of them manages real-time signals that are specific to their role in the drilling process. However, the optimization of drilling performance and the reduction of drilling risks necessitate a transparent and efficient exchange of available real-time signals between the various participants in the drilling operation.

Efficient real-time signal exchange can be achieved by utilizing real-time dedicated transfer protocols like OPC-UA (OLE for Process Control-Unified Architecture), but seamless data exchange between multiple data providers and consumer applications necessitates the definition of description of drilling real-time signals that allows computer programs to infer, without human intervention, which signals are the most suitable for its own usage.

A semantic description of drilling real-time signals shall allow computer programs to discover which signals are available at any time, make inferences to determine the meaning of each signal, and provide sufficiently detailed information to make informed choices between signals of equivalent nature. When this is in place, it is possible for software applications to adapt themselves to the currently available real-time signals. One example of such a situation is when downhole pressure measurements are not available before the downhole telemetry system is operational. Another example is related to the present state of the drilling system, including possible variations of the rig configuration like for instance when utilizing intermittently a booster pump to increase the flow-rate in a marine riser, or when activating downhole tools, like opening or closing an under-reamer.

In DrillWell a demonstration of an initial prototype was held in October 2017. The demonstration focused on three examples that are typically encountered when establishing circulation after tripping in an open hole. For more information about the demonstration see http://drillwell.no/home/drilling-data-hub-demonstration.



Flow of information during drilling – Intermediate interface reference implementation.

PROGRAMME 1

Well control with along-string measurements

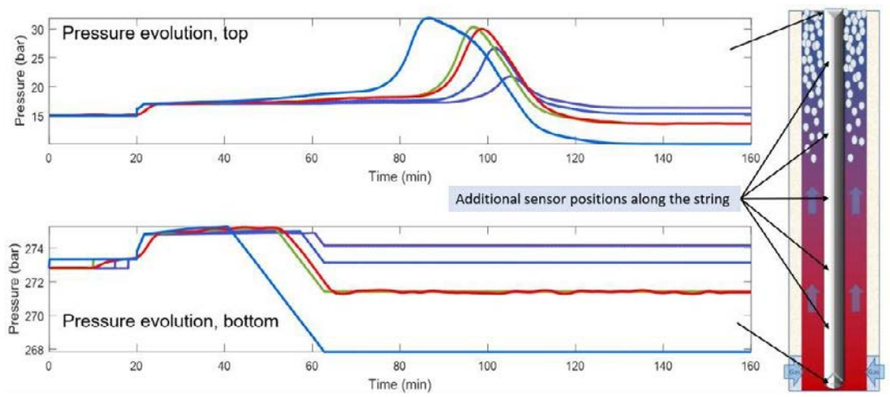
Using wired drill pipe or other technology that enables real-time recordings of pressure and temperature along the wellbore during well control operations, opens new possibilities for accurate monitoring and interpretations while circulating out a kick.

Deviation between measured and expected downhole process conditions has many potential causes. Expected process conditions rely in most cases heavily on calculations, and using the most accurate well control related mathematical models reduces uncertainty and gives improved discrimination among the potential causes.

The basic idea is to run many simulations with uncertain input parameters and assumptions varied within a likely range. Then, as information is gathered in real time from sensors along the well, combinations of parameters and assumptions that clearly disagree with measurements are discarded such that only the more likely simulations are kept. The problem when there is only one or a few sensor positions, is that many different combinations of parameters/assumptions may explain the observations within the range of uncertainty, which makes it hard to conclude firmly on values of individual parameters and validity of assumptions. The ability to interpret the downhole situation improves dramatically with the number of sensor positions, which with along-string measurements can be as much as five or more. To realise the full potential of this, it is important that the mathematical models represent the physics as accurately as possible. Otherwise, conclusions may only partly reflect physics, as the selection process partly will deal with correcting model deficiencies.

Several approaches can be used, depending on how fast and robust calculations are. Using for example a Monte Carlo type technique, thousands of pre-simulations can be run to span ranges of uncertain input parameters and assumptions. Then a very fast and robust real-time algorithm can make choices and discard simulations that do not match measurements. Alternatively, multiple simulations can be run in parallel in real-time, with parameter tuning by Kalman filtering or similar.

The curves below illustrate how this can be done, with examples from two selected sensor positions. With five or more sensor positions, a much larger set of simulations can be discriminated down to a very small number of simulations that match the measurements.



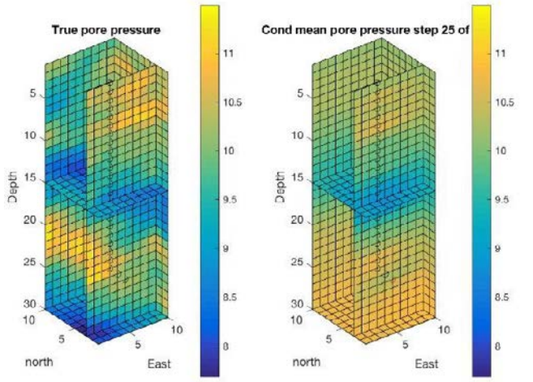
Gas kick event: Pressure recordings (red) and simulations (blue, best fit in green) with different kick volumes.

PressureAhead

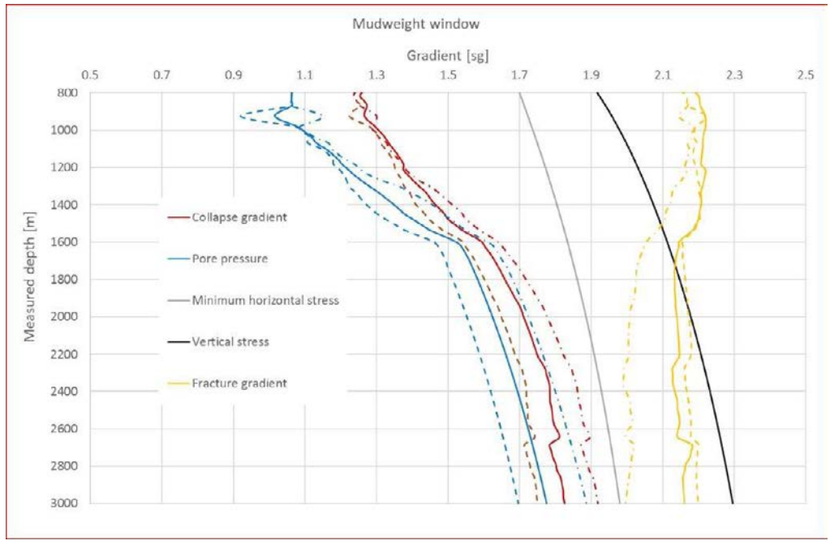
The PressureAhead project introduces new methods to reduce the uncertainties in geo-pressure prediction ahead of the bit. With better control of the pore pressure in the underground, it is easier to use correct mud-weight while drilling and this will result in cost reduction and safer drilling campaigns.

Wrong assumptions regarding pressure and mud weight, may lead to non-productive time due to mud loss, stuck pipe and well control incidents. In this project the objective is to reduce the uncertainty in predictions of overpressures and mud window ahead of the bit. Since the input data is uncertain and our understanding of the processes is limited, thousands of simulations are carried out to simulate the most likely pressure profile. Thereafter, the most likely mud weight window along the planned well path is generated. We aim to update the pressure prognosis and the mud window by using available real-time drilling data from logs to improve predictions ahead of the drilling bit.

The project started in 2016 and will last till end of 2018. During the first years of the project, our focus has been addressing uncertainties in the modelling of the pore pressure and mud window. During the last year, the new methodology will be tested on data from the North Sea.



New methods for uncertainty prediction around a planned well path have been tested. From Paglia & Eidsvik (2017).



Uncertainty in pore pressure from Pressim is used as input into the mud weight window prediction using PSI. The figure shows how the uncertainty in pore pressures (blue curves) has a significant impact on the fracture gradient (yellow curve) and on the collapse gradient (red curves). With increased overpressure, the fracture gradient will be reduced, and the mud weight window becomes narrower. From IADC/SPE-189665-MS (Lothe et al. 2018).

Torbjørn Vrålstad,
Programme Manager

PROGRAMME 3:

Well solutions for improved recovery

Ensuring well integrity is important to prolong well lifetime and to minimize leakages to the environment. DrillWell's Programme 3 is contributing significantly to achieve this.

All projects in Programme 3 address cement integrity and zonal isolation in one way or another, and the overall aim is to obtain a more scientific understanding of barriers. Most activities have an experimental nature and advanced laboratory facilities have been constructed to study cement integrity.

In 2017, we have made good progress in all projects. New and interesting results have been obtained while previous deliverables have been matured and applied. Furthermore, experimental know-how and methodologies from Programme 3 are now used in projects within renewable energy topics such as geothermal wells and Carbon Capture and Storage (CCS).

An important aspect of Programme 3 is the closeness to the industry; i.e. with the operators and industry partners in DrillWell, major service companies such as Halliburton and Schlumberger, and smaller, more technology-specific vendors. This direct involvement of the service industry improves the quality and relevance of the obtained results and ensures application of deliverables.

There are now four ongoing projects in Programme 3, where two of these are KPN projects with additional funding from PETROMAKS2.

Projects in Programme 3:

- P3.2 Life cycle cement integrity (Project manager: Torbjørn Vrålstad)
- P3.5 KPN Cementing irregular wellbore geometries (Project manager: Hans Joakim Skadsem)
- P3.6 Technologies for barrier evaluation and P&A (Project manager: Dave Gardner)
- P3.7 KPN Leakage risk assessment for plugged and abandoned oil and gas wells (Project manager: Eric Ford)

Meet Anisa Noor Corina, researcher at NTNU

- In my spare time, I like to spend my time reading novels, drawing, or play the guitar.

PROGRAMME 3

Name: Anisa Noor Corina

Age: 25

Nationality: Indonesia

Education: BSc in Petroleum Engineering at Institut Teknologi Bandung and MSc in Petroleum Engineering at NTNU

Department: Department of Geoscience and Petroleum, NTNU

What are you working on right now?

For my PhD project, I am working on the integrity of cement placed inside the casing (cement plug) for the abandonment phase. The project includes experimental work using a small laboratory set-up that imitates the cement plug at realistic downhole conditions. The set-up was designed to investigate the sealing ability of cement plug by flowing gas through the cement bulk.

Why do you find this interesting?

I found this is interesting because the amount of research related to this topic is still limited, while cement plug quality is very crucial to well barrier in abandonment phase. It has encouraged me to join the project and investigate the case. In addition, the working environment at NTNU and SINTEF has an exceptional appeal to me because of the extensive collaboration and profound discussion with experts involved in the project.

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

Yes, absolutely. In my opinion, the biggest advantage of working together with the industry is that I can see oil and gas fields from a different point-of-view. Specifically, to my current project, inputs based on the real application of cement plug, e.g. type of cement, additives, or casing, can be helpful to adjust the project task, and hence the results can also be beneficial for the industry.

Do you see yourself working within oil and gas in ten years' time? If yes, doing what?

Since I started my BSc within petroleum engineering, I have always pictured my future-self working in oil and gas industry. But for now, I still have a vague picture of my future work in 10 years because I am open to any opportunities. I do enjoy doing research but pursuing an industry career is not a closed-option for me. So, only time will tell.

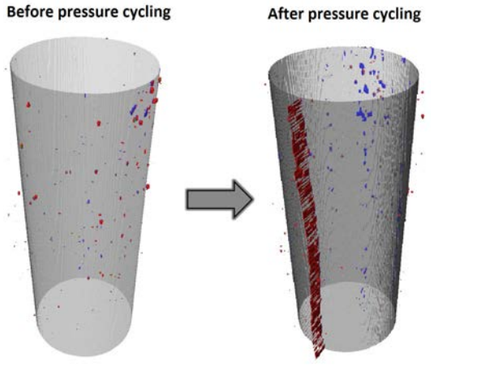
PROGRAMME 3

Life-cycle cement integrity

Cement is one of the most important barrier materials in the well. The aim of this project is to experimentally study degradation mechanisms and sealing ability of cement sheaths and cement plugs. Such an improved understanding of cement integrity will lead to fewer well integrity problems both during production and after abandonment.

A unique laboratory set-up has been built in this project to study the integrity of annulus cement sheaths when exposed to pressure cycling. Cement degradation mechanisms such as formation of radial cracks and microannuli in the cement sheath are quantified and digitally visualized in 3D by X-ray Computed Tomography (CT). During 2017, it was observed that radial cracks are formed in the cement sheath when exposed to sufficient casing pressure, and it was verified that contextual well conditions such as the type of surrounding rock determine how much pressure the cement can withstand before failure.

Furthermore, the integrity of cement plugs is studied in a dedicated experimental set-up, where different cement systems are tested at relevant well conditions. The sealing ability of the plugs are determined by measuring gas flow through or around the plug for different pressure differences. During 2017, it has been confirmed that the set-up is working well with repeatable and reliable experimental conditions, and good baseline test results have been obtained.



CT visualization of radial cracks formed in the cement sheath during pressure cycling.

Laboratory set-up for experimental tests of cement sheath integrity.

Per Simensen, project manager at Ullrigg, Stavanger.

PROGRAMME 3

Cementing irregular wellbore geometries

The primary cementing of casing is among the most critical operations during well construction and one that affects the entire life cycle of a well. The objective of this project is to improve our understanding of fluid displacement and cementing in wellbores with irregular annulus geometry through experiments and numerical simulations.

To investigate cement placement in an annulus with realistic diameters, experiments involving a water-based spacer displaced by a conventional class G cement slurry were performed at IRIS in 2017. Four annulus test assemblies were constructed and instrumented by Ullrigg Drilling and Well Centre and consisted of 7" tubing inside 9 5/8" casings. A short 16" casing section representing a washout was mounted on three of the assemblies. Instrumentation included flow rate, pressure and temperature transmitters, as well as conductivity probes for tracking the fluid-fluid interface. The choice of conductivity probes was based on experiment experience from displacement campaigns at SINTEF in 2016.

The assemblies were initially filled with spacer fluid, and the experiments consisted of injecting cement slurry at different flow rates and with varying spacer conditioning. The inner 7" tubing rested on its collar on the low side of the annulus, giving a standoff of no more than 47 percent in the experiments. Initial results suggest some pockets of spacer remain in parts of the enlarged sections, and that the density difference between spacer and cement slurry assists in directing slurry to the narrow side of the annulus. Further pressure, leakage and ultrasonic testing is planned for 2018. The project had excellent collaboration with Halliburton, who provided cement slurry and spacer fluid design, and who headed the on-site fluid mixing.

The four test assemblies constructed with 7" tubing inside 9 5/8" casing and 16" washout section.

Technologies for barrier evaluation and P&A

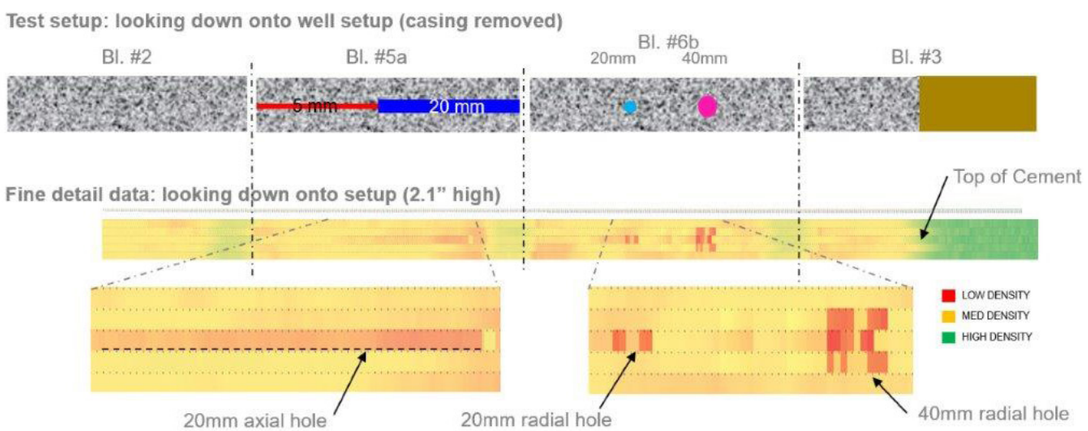
When designing a plug and abandonment (P&A) operation the barrier quality of the casing cement sheath must be assessed such that an optimal P&A solution can be chosen. The objective of this project is to construct a full-scale facility and execute experiments for the purpose of evaluating commercial and emerging barrier verification technologies. A particular aim is to support the development of technologies for logging through multiple tubulars.

Barrier reference cells and test blocks have been constructed and used to investigate the performance of different logging technologies. The cells are built from 7" tubing cemented inside 9 5/8" casing with a range of cement sheath qualities, including annular leakage scenarios such as gas channels, mud channels and de-bonded cement. Four industrial experiments have been performed so far, encompassing commercial logs, alternative barrier verification technology and a new X-ray concept that potentially can log through multiple tubulars.

An experiment with the Visuray VR360 X-ray concept was executed utilizing eight test blocks built for this purpose. The objective was to investigate the measurement resolution and the ability of X-rays to detect different defects deep in the cement behind the casing with and without a micro-annulus. The Visuray concept mock-up was safely remotely operated, below ground level in the Ullrigg HETE test pit which shielded the surrounding environment from the emitted radiation. The experiment was managed by qualified industrial radiologists from the technology developers own organization and was executed without incident. It was demonstrated that X-ray based cement, evaluation can detect defects even when there is debonding between the inner casing and the cement and defects located away from the inner casing/cement interface can also be seen.

A Post Doc fellow started work in 2017 initially focusing on the design of a "Shale as a Barrier" reference cell and a paper will be presented at OMAE2018.

Noise logging experiment using sound proofed reference cells installed in the Ullrigg HETE test pit.



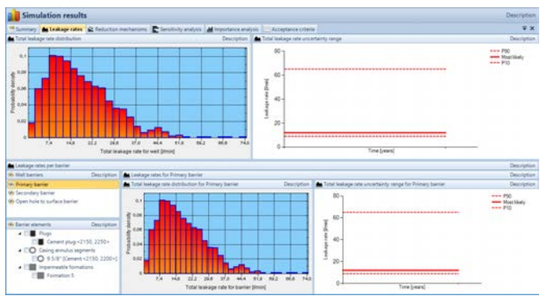
2-D image showing cement defects detected by X-rays scanning four test blocks during the Visuray VR360 concept experiment.

Leakage risk assessment for plugged and abandoned oil & gas wells

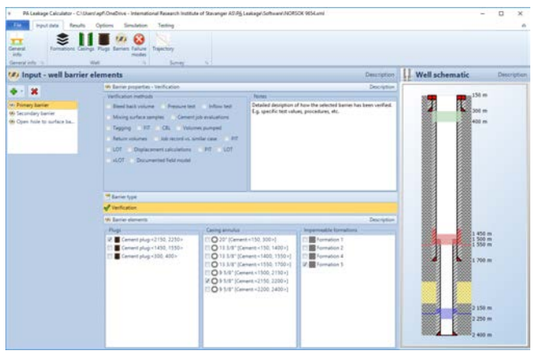
P&A well design performed on the NCS today follows a best practice approach. This means that the selected P&A solution either adheres to NORSOK D-010, meaning the well shall not leak in an "eternal" perspective and the P&A costs should be as low as possible, or even stricter company standards set by the different operators. While such an approach may give satisfactory results in terms of the first criterion, it does not help the industry improve with respect to reducing cost.

In order to combine and possibly trade-off the two success criteria, there is a need for a methodology that can quantify the quality of a given P&A solution. A quality measure that is easy to communicate and that can be quantified is the risk of leakage from a given P&A design, i.e. the probability that a leak will occur and the corresponding leakage rate. The development of a methodology for such a quality measure, is the objective of this project.

During 2017, the project has had a focus on furthering modelling efforts, with post-abandonment pressure modelling in the North Sea, and modelling related to leakage estimation, considering micro annuli size estimation, rate reduction factors and gas diffusion. A model for leakage outside the wellbore through the surrounding formations has also been established, and work has begun to establish a foundation and modelling approach with respect to acceptance criteria for leakage rates. The software tool has a graphical user interface in place for many of the main input categories and a beta version will be issued for testing to the industry partners in early 2018.



Software graphical user interface for results, where total leakage rates and leakage rates per barrier are shown.



Software graphical user interface for defining well barrier elements and related properties.

DrillWell
DRILLING AND WELL CENTRE
FOR IMPROVED RECOVERY

PhD students

MARIUS STAAHL NILSEN

Department: Department of Geoscience and Petroleum, NTNU

Main topic of PhD Thesis: Dynamic behavior of formation gas in oil-based mud

Main contribution to the research field: My research aims to describe the dynamic behavior when gas is liberated from a saturated mud during pressure depletion. As large quantities of formation gas can be dissolved into an oil-based mud during a gas kick, it is important to understand when, and at what rate, free gas will appear in the wellbore.

ANISA NOOR CORINA

Department: Department of Geoscience and Petroleum, NTNU

Main topic of PhD Thesis: Cement plug integrity within plug & abandonment phase

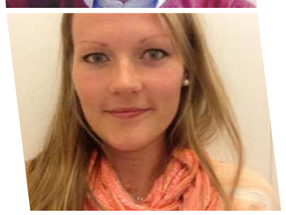
Main contribution to the research field: The objective of this project is to study the sealing ability of cement plug throughout the life-cycle of the well, especially during the well P&A phase. The tasks will focus on determining the sealing ability of cement plugs at different conditions, such as effect of additives (with an emphasis on expandable cement), presence of mud, plug length, etc.

JACOPO PAGLIA

Department: Department of mathematical sciences, NTNU

Main topic of PhD Thesis: Statistical models for pore pressure prediction and drilling window

Main contribution to the research field: Build statistical models for the pore pressure over a spatial domain and linking this variable to measurements made in wells. The key goal is to predict the pore pressure (with uncertainties) at various depths, ahead of the drill-bit, before the well is drilled to that depth. Pore pressure prediction will be connected with the mud-weight window characteristics.



SOLVEIG RIISØEN

Department: IRIS Energy - Drilling and Well Modelling

Main topic of PhD Thesis: A study on the accuracy of the modelled frictional pressure loss based on rheological characterization of the drilling fluid

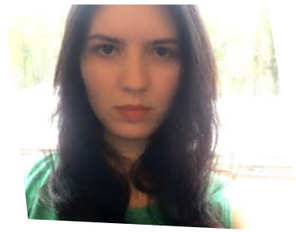
Main contribution to the research field: The overall objective of this project is to investigate the accuracy of the modelled frictional pressure loss of a typical drilling fluid, using a rheology curve produced by a Couette type rheometer and later look at the effect of solids particles on the predictability of frictional pressure loss.

SHREYANSH DIVYANKAR

Department: Petroleum Engineering, University of Stavanger

Main topic of PhD Thesis: Cementing irregular wellbore geometries

Main contribution to the research field: The research work aims to study velocity profiles in irregular (washouts and eccentricity) wellbore geometries and gain a better understanding of displacement efficiency during primary cementing.



DALILA DE SOUSA GOMES

Department: Petroleum Engineering, University of Stavanger

Main topic of PhD Thesis: Improved dynamic modelling of two phase flow in well control operations

Main contribution to the research field: The thesis work is about how we can improve transient flow models for better prediction of well control scenarios with focus on oil-based muds. The plan is to also integrate new PVT sub-models under development in DrillWell. Improved models can be used for increased knowledge about safety critical issues, training as well as providing input to procedures. Improved models can be used for developing tools that can be used in an operational environment.

DrillWell Post Docs

Name: Geir-Ove Strand
Department: Geoscience and Petroleum, NTNU
Main topic of post doc thesis: Technologies for barrier evaluation and P&A with special focus on ‘technologies for shale barrier evaluation in the North Sea’.

The objective of plugging and abandonment (P&A) is for a well to be isolated ‘forever’. The long-term sealing requirement is a critical factor in a highly regulated North Sea environment, and the industry two-barrier rule suggests that plug isolation needs to be verified by testing or equivalent method independent of material used for P&A. The acceptance criteria and the means for verification of plugs will as such be critical to identify the optimal P&A solution. It has been suggested that cement evaluation tools can be used to help verify the presence of a shale formation that has formed a barrier outside the casing.

The ability of these tools to help determine an acceptable well leakage risk level, however, remain a subject of dispute in the industry. In this DrillWell sub-project we aim to present results that may help contribute to resolving this dispute. The sub-project objective is to design and build a full-scale ‘shale as barrier’ reference calibration cell. The reference cell is to be designed and made accessible to existing and emerging annulus barrier evaluation methods. The purpose is to help increase the quality of decisions made from such barrier evaluation technologies in an explicit well P&A safety context.

Name: Ulf Jakob Flø Aarsnes

Department: IRIS Energy – Drilling and Well Modelling

Main topic of post doc thesis: Interaction of drill string vibrations, cuttings transport and well hydraulics.

Drill string vibrations, and their negative consequences on ROP and equipment, is a well-known phenomenon when drilling, in particular the torsional oscillations known as stick slip. During this work we have extended the analysis of drill string vibrations, as caused by bit-rock interaction and drill string-wellbore interaction, from simplified lumped models to more realistic distributed models. This enables us to capture the full range of torsional dynamics regardless of well length and survey, which is needed to extend the current knowledge and existing mitigation techniques to include drill string behavior in long and deviated wells.

The variation of the drill-string rotational velocities will also affect the transport of cuttings, which in turn will affect not only the pressure losses but also the mechanical friction. In the continued research effort we aim to characterize these effects to enable improved cutting transports modelling and vibration detection.

Name: Fatemeh Moeinikia

Department: Petroleum Engineering, UiS/Risk Management and well construction group, IRIS Energy

Main topic of post doc thesis: Leakage risk assessment for plugged and abandoned oil and gas wells.

In the coming decades, thousands of wells will have to be plugged and abandoned (P&A) on the Norwegian Continental Shelf (NCS). P&A well design performed on the NCS today follows a best practice approach. Such an approach does not say anything about the quality of a P&A solution in terms of its hydrocarbon sealing capabilities in the long-term, thus making it challenging to introduce alternative P&A well design and technologies.

This KPN project aims to enable the operators to put a quality measure on any given P&A well design. 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.

CEO of GCE NODE, Anne-Grete Ellingsen and Research Scientist, Jan Einar Gravdal at the NorTex seminar and workshop. Photo: GCE NODE

International collaboration

NORTEX OTC 2017 DIGITALIZATION WORKSHOP

The 2017 NorTex Digitalization Workshop was held at the OTC conference and exhibition in Houston and was done in collaboration between DrillWell, GCE NODE and its partners in NorTex Data Science Cluster.

The workshop took place on May 3rd and session one was about *Collaborating on common standards*. Session two was about *Securing reliable and safe data* and session three was focusing on *Transforming data to advisory*.

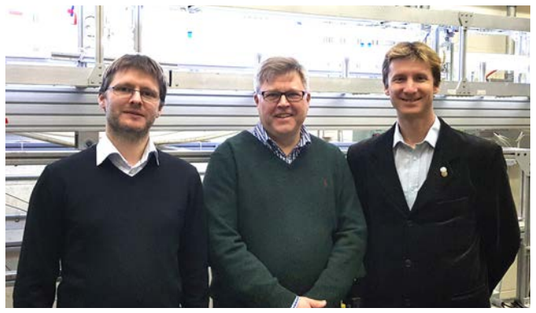
The workshop was a continuation of discussions launched during OTC 2016 in Houston, with a focus on digitalization and effective interoperability. The goal is to share information about current projects across borders and entities as well as strengthening partnerships and collaboration. The programme committee consisted of: Fionn Iversen (IRIS), Ann Marchioro and Arnt Aske (GCE NODE), John Macpherson (Baker Hughes/SPE DSATS) and Jan Odegaard (Rice University).

VISIT TO UBC IN VANCOUVER

In the beginning of 2017 Jan David Ytrehus and Torbjørn Vrålstad from SINTEF visited Professor Ian Frigaard in Vancouver, Canada. He is professor of fluid mechanics at University of British Colombia (UBC).

An important objective of the visit was to present and discuss the recently obtained experimental results on cement displacement in washouts from DrillWell KPN-project "Cementing irregular wellbore geometries". Ian Frigaard arranged an informal two-day seminar with his students, where various cement-related issues were presented and discussed. Ian and his students gave several interesting presentations on cementing topics such as displacement in irregular annuli, gas channeling, microannuli formation, cement hydration, displacement in pipes, and plug & abandonment.

In addition to the presentation of experimental results on cement displacement in washouts by Jan David Ytrehus, Torbjørn Vrålstad also gave a presentation on cement integrity and fluid flow through microannuli and cracks based on results from DrillWell-project "Life-cycle cement integrity".



At University of British Colombia (UBC). From left: Torbjørn Vrålstad, Ian Frigaard and Jan David Ytrehus. Photo: SINTEF

Jan Einar Gravdal, IRIS, was one of the researchers joining OTC on behalf of DrillWell.

Communication and dissemination activities

DrillWell has a strong focus on the continuous improvement of communication and visibility. During 2017 DrillWell has presented research results at several conferences showing a leading edge in the digitalization and automation of drilling operations and well technology.

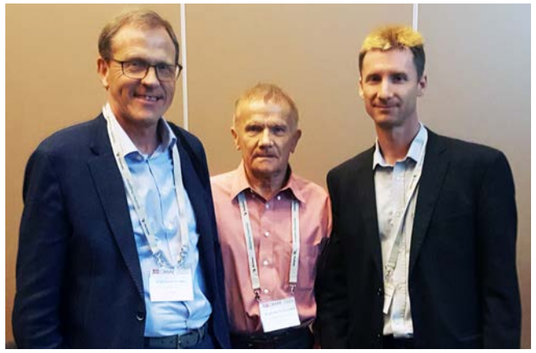
LEADING ANNUAL DRILLING CONFERENCE

The SPE/IADC Drilling Conference and Exhibition was held from March 14th -16th in Hague. DrillWell was represented at the conference with as many as five presentations based on the research results from the three DrillWell projects: Drilling process optimization, Well control simulator and Gas in oil-based mud.

EXPERIMENTAL P&A RESEARCH FOR THE NORTH SEA

The latest developments within P&A research were presented in Trondheim on March 20th and 21st and DrillWell were well represented with three presentations. SINTEF Petroleum hosted the conference where the emphasis was on relevant experimental R&D within P&A. Approximately 160 people attended the conference that consisted of 24 presentations, a tour of SINTEF's laboratory facilities and a panel debate at the very end.

The NTNU Drillbotics team. From the left: Astrid Lescoeur, Runa Linn Egeland, Martin Aagaard Olsen and Mayuran Vasantharajan. Photo: Sigve Hovda



At OMAE: DrillWell director Sigmund Stokka, professor Andrew Wojtanowicz and Jan David Ytrehus, researcher at SINTEF.

OTC – AN IMPORTANT EVENT

From May 1st-4th more than 64,700 persons attended the annual Offshore Technology Conference (OTC) in Houston, and it was a significant opportunity for both networking and industry meetings. DrillWell' s exhibition stand generated a lot of interest and in addition the DrillWell representatives had several meetings with industry-partners. OTC showed that DrillWell research attracts international interest and it is important to be visible at this type of event. The DrillWell annual report was a popular handout during the event.

OMAE IN TRONDHEIM

The 36th International Conference on Ocean, Offshore and Arctic Engineering was held in Trondheim, Norway from June 25th to June 30th, 2017. DrillWell was well represented with many presentations at the Petroleum Technology Symposium, including a special session dedicated to DrillWell.

CLOSE RACE AT DRILLBOTICS

At the 2017 Drillbotics competition it was a very close race in the final. The winning team from Texas A&M University was closely followed by DrillWell partners Norwegian University of Science and Technology (NTNU) and University of Stavanger (UiS). The students from UiS have been co-supervised by IRIS personnel as part of the DrillWell project "Drilling Process Optimization". The competition requires both theoretical and practical knowledge and the two universities that collaborate with DrillWell came in 2nd and 3rd in competition with major universities from the U.S and Germany.

DRILLWELL.NO
posts centre news on a regular basis

NEWSLETTERS
are distributed every three months

DrillWell is active on social media, follow us!

New safe artificial rock for plug and abandonment

Based on his PhD research at DrillWell Mahmoud Khalifeh has developed a new material of geopolymers that could become a game changer for plug and abandonment operations.

One of the main components of this safe artificial rock is norite. Norite is a waste material from the mining industry in Norway, so this new material also has great potential for saving the environment.

- When I started my PhD in September 2012, the scope of the project was to identify a material for plug and abandonment that had three characteristics: 1) Shall be pumpable like cement slurry, 2) No shrinkage or less shrinkage than cement and 3) Impermeable as cap rock, Dr. Khalifeh explains.

8 RESEARCH PAPERS

After a lot of research including 4 journal papers and 4 conference papers and a comprehensive series of testing and failing, Dr. Khalifeh has now produced a prototype of artificial rock that is pumpable like cement. And it shrinks only 0.5 percent, compared to neat cement which shrinks approximately 3-4 percent. Moreover, it has one thousand times less permeability than oil well cement, which means that it offers lower risk of leakage across the artificial rock.

70 PERCENT LESS CO_2 EMISSION

Using the low pH waste norite from the mining industry is not the only environmental advantage. When manufacturing ordinary cement the heating process in the rotary kiln generates some 650 kg of CO_2 when producing one ton of cement. Worst case up to 900 kg of CO_2. - The production of the artificial rock emits approximately 70 percent less CO_2 compared to ordinary cement, which is quite remarkable, Dr. Khalifeh says.

SAFE ROCK

- The norite-based rock can be described as safe, Dr. Khalifeh continues. It has been heat tested at 1 000 °C and after that cooled down with water at 8-9 °C without developing any cracks, staying in shape, unaffected by the high temperature and the sudden temperature change.

PATENTED

Mahmoud Khalifeh defended and finished his PhD dissertation 4 months ahead of schedule on May 20th 2016. After that he has been working as Postdoctoral fellow and assistant Professor at University of Stavanger (UiS) and he has two patents now. One for aplite-based cementitious, geopolymeric material and one for norite-based cementitious geopolymeric material. - I am very thankful for the three years at DrillWell that provided me with a fantastic environment, acknowledgeable and motivated supervisors (Prof. Helge Hodne, Prof. Arild Saasen and Dr. Torbjørn Vrålstad) and industrial contacts throughout my research career. It was a very interesting project between UiS and DrillWell centre with preset goals, Dr. Khalifeh says.

OTHER INDUSTRIES

Dr. Khalifeh is of course eager to see the potential of this new artificial rock unleashed within plug and abandonment, but at the same time he says that there is a great potential for using it within normal construction work on buildings and other constructions where safety is a big issue such as tunnels, banks etc.

These findings are described in Dr. Khalifeh's latest research article published August 23rd 2017:

Development and Characterization of Norite-Based Cementious Binder from an Ilmenite Mine Waste Stream.

"I am very thankful for the three years at DrillWell that provided me with a fantastic environment, acknowledgeable and motivated supervisors and industrial contacts throughout my research career."

Mahmoud Khalifeh

The annual DrillWell seminar

The annual DrillWell seminar at Sola Strand Hotel in September was a great success, gathering more than 100 participants from both industry and research partners. The two-day seminar proved that digitalization is an increasingly important factor for improving drilling and well technology.

The first day of the seminar focused on the digital transformation and digitalization of drilling technology and was moderated by Research Director at IRIS, Helga Gjeraldstveit.

DrillWell manager, Sigmund Stokka opened the meeting and emphasized the importance of the DrillWell research centre and the good co-operation with the industrial partners.

The second day of the seminar continued in the digital track and the presentations showed us that CT scanning and X-ray are widely used in research and development of cementing and P&A technology.

FOCUS ON DIGITALIZATION

Senior research scientist at IRIS and member of the DrillWell management group, Jan Einar Gravdal was very satisfied with this year's seminar. – Here, we can focus specifically on the R&D areas that we address in DrillWell. This year we wanted to focus on digitalization, and I believe we managed to do that quite well. The seminar is very important for us to align our goals with the industry. We are very satisfied with the number of participants in this year's seminar.

- For the seminar the contributions from operating companies in terms of knowledge sharing and implementation of new technologies supporting drilling automation and digitalization was very well received, added Research Director at SINTEF and DrillWell management group member, Harald Linga. Also the value of understanding rock mechanics, supported by examples of the utilization rock formation characteristics of the alleviation of leakages from the well, was demonstrated. This topic, being a part of the P&A sessions, has significant potential for cost reductions for P&A.

Technical Committee member from ConocoPhillips, Stein Håvardstein, said that the 2017 DrillWell seminar gave an interesting insight in many different perspectives, industry ambitions and research initiatives from both the industry partners and the research institutes. - The seminar demonstrated the drive towards increase of digitalization in the drilling and well industry as well as improve quality and cost reduction in the P&A operations.

Dr. John L. Thorogood, drilling engineering advisor at Drilling Global Consultant LLP and member of the DrillWell scientific advisory committee also commented on the seminar.

GREAT ENGAGEMENT

- It was an excellent set of presentations by DrillWell scientists and industrial end users. The work is truly leading edge both on the automation side and also within P&A. The seminar is well organized and a valuable showcase for the DrillWell activities. More effort should be devoted to getting attendance from the other Norwegian operators and also from the UK, the Oil and Gas Authority and also the Oil and Gas Technology Centre. These people really do need to know of the exciting stuff going on in Norway, Dr. Thorogood concluded.

- It was a great pleasure to experience such engagement from oil & gas companies, suppliers and researchers. New research results and how to use new technology within drilling, cementing and P&A were presented by highly engaged speakers. The breaks during the day were used for socializing, discussion and exchange of experience. - This is just as important as the presentations, DrillWell manager Sigmund Stokka concluded at the end of the seminar.

The annual seminar was held at Sola Strand Hotel. From left: Jacobo Paglia, NTNU, Reina Teelken, NOV and Anisa Noor Corina, NTNU.

Beautiful view at Sola beach.

Øyvind Salvesen, Research Council of Norway and Helga Gjeraldstveit, Research Director at IRIS.

DRILLWELL RESEARCHERS

Helga Gjeraldstveit	IRIS	Drilling and well technology
Dave Gardner	IRIS	Drilling and well technology
Hans Petter Lohne	IRIS	Drilling and well technology
Jostein Sørbø	IRIS	Drilling technology
Jan Einar Gravdal	IRIS	Drilling physics
Erlend H. Vefring	IRIS	Drilling physics
Fionn Iversen	IRIS	Drilling physics
Johnny Petersen	IRIS	Drilling physics
Erich Suter	IRIS	Computer modelling
Sergey Alyaev	IRIS	Computer modelling
Steinar Kragset	IRIS	Computer modelling
Xiadong Luo	IRIS	Mathematical modelling
Øystein Arild	IRIS	Risk analysis
Eric Cayeux	IRIS	Drilling and well modelling
Benoit Daireaux	IRIS	Drilling and well modelling
Erik Dvergsnes	IRIS	Drilling and well modelling
Sonja Moi	IRIS	Drilling and well modelling
Amare Leulseged	IRIS	Drilling and well modelling
Hans Joakim Skadsem	IRIS	Drilling and well modelling
Gunnstein Sælevik	IRIS	Drilling and well modelling
Liv A. Carlsen	IRIS	Drilling and well modelling
Kjell Kåre Fjelde	UiS	Drilling and well modelling
Reidar Bratvold	UiS	Reservoir technology
Terje Kårstad	UiS	Computer science
Dan Sui	UiS	Computer modelling
Mahmoud Khalifeh	UiS	Plug and avandonment
Helge Hodne	UiS	Fluid mechanics
Rune W. Time	UiS	Fluid physics
Knut Steinar Bjørkevoll	SINTEF	Drilling and well modelling
Jan Ole Skogestad	SINTEF	Drilling and well modelling
Manuel Aghio	SINTEF	Drilling and well modelling
Johnny Frøyen	SINTEF	Drilling and well modelling
Idar Larsen	SINTEF	Formation physics
Torbjørn Vrålstad	SINTEF	Well integrity
Thomas Monge Øia	SINTEF	Well integrity
Ragnhild Skorpa	SINTEF	Well integrity
Kamila Gawel	SINTEF	Well integrity
Nils Opedal	SINTEF	Well integrity
Bjørnar Lund	SINTEF	Fluid mechanics
Bård Bjørkvik	SINTEF	Fluid mechanics
Jelena Todorovic	SINTEF	Drilling physics
Harald Linga	SINTEF	Drilling and well technology
Ali Taghipour	SINTEF	Drilling and well technology
Jan David Ytrehus	SINTEF	Drilling and well technology
Ane Lothe	SINTEF	Basin modellig
Peder Eliasson	SINTEF	Geophysics
Anouar Romdhane	SINTEF	Geophysics
Børge Arntsen	NTNU	Applied geophysics
Sigbjørn Sangesland	NTNU	Drilling engineering
Pål Skalle	NTNU	Drilling engineering
Sigve Hovda	NTNU	Drilling engineering

DRILLWELL PUBLICATIONS

JOURNAL

Aarsnes, U.J.F., Acikmese, B., Ambrus, A. and Aamo, O.M. 2016. ''Robust Controller Design for Automated Kick Handling in Managed Pressure Drilling''. Journal of Process Control, vol 47, November, pp46-57.

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Suter, E., Friis, H.A., Vefring, E.H., Kårstad, T., Escalona, A. 2017. "A novel method for multi-resolution earth model gridding". SPE-182687-MS. Presented at the SPE Reservoir Simulation Conference held in Montgomery, TX, USA 20–22 February.

Torsvik, A., Myrseth, V., Linga, H. 2015. "Drilling fluid rheology at challenging drilling conditions –an experimental study using a 1000 bar pressure cell". presented at the Nordic Rheology Conference in Karlstad, Sweden, August 19-20. Paper published in Annual Transactions of the Nordic Rheology Society.

Torsvik, A., Skogestad, J.O., Linga, H. 2016. "Impact on Oil-Based Drilling Fluid Properties from Gas Influx at HPHT conditions". Paper IADC/SPE-178860 presented at the coming SPE Drilling conference in Fort Worth, TX, USA, March 1-3.

Torsæter, M., Opedal, N., Vrålstad, T., Vullum, P.E 2013. "A Visual Journey into the 3D Chemical Nanostructure of Oilwell Cement". Paper SPE 164105 presented at the SPE International Symposium on Oilfield Chemistry held in The Woodlands, Texas, USA, 8–10 April.

Valestrand, R., Khrulenko, A., Hatzignatiou, D.G. 2014. "Smart Wells for Improved Water Management in the Presence of Geological Uncertainty". Paper SPE 169223 presented at the SPE Bergen One Day Seminar, April 2.

Vrålstad, T., Skorpa, R., Opedal, N., De Andrade, J. 2015. "Effect of thermal cycling on cement sheath integrity: Realistic experimental tests and simulation of resulting leakages". SPE-178467-MS presented at the SPE Thermal Well Integrity and Design Symposium, Alberta, Canada, November 23-25.

Vrålstad, T., Todorovic, J., Saasen, A., Godøy R. 2016. "Long-term Integrity of Well Cements at Downhole Conditions". Paper SPE-180058-MS presented at the SPE One Day Seminar, Bergen, April 20.

PRESENTATIONS WITHOUT PAPER

Aarsnes, U.J.F.,Van de Wouw, N. 2017. "Axial and torsional dynamics of a distributed drill string system". 9th European Nonlinear Dynamics Conference.

Aarsnes, U.J.F., Roman Shor 2017. "Stick-slip and Torsional Friction Factors in Inclined Wellbores". International Conference on Engineering Vibration, Sofia, Bulgaria, September 4-7.

Aarsnes, U.J.F., Van de Wouw, N. 2017. "Axial and torsional dynamics of a distributed drill string system". European Nonlinear Dynamics Conference (ENOC), June 25-30, Budapest, Hungary.

Aas, B. 2014. "Plugging and abandonment with tubing left in hole". Presented at P&A Forum, Stavanger, June.

Aas, B. 2014. "The DrillWell project – Tubing left in hole". Presented at the Kristiansand Drilling and Well Conference, NPF, September 16.

Gardner, D. 2017. "Well P&A, evaluating the barrier system quality". Kristiansandkonferansen innen boring og brønn.

Askarinezhad, R., Hatzignatiou, D., Stavland, A. 2016. "Improved Disproportionate Permeability Reduction Treatment Process: A Laboratory Scale Approach". Presented at the NPF conference: Reservoir & Production Management, Stavanger, November 28-29, 2016.

Cayeux, E. 2014. "Getting it Right: Balancing Model Complexity, Margin and Risk with the Right Measurements". Key Note at Celle Drilling International Conference and Exhibition for Advanced Drilling Technology (SPE/IADC), September 15-16.

Cayeux, E. 2016. "Cutting transport and drilling optimization". Presented at The annual DrillWell seminar, Sola Strand Hotel - September 27-28.

Cayeux, E. 2016. "Requirements for data transfer in a multivendor environment to support drilling automation". Presented at the Morning Seminar – Data for Drilling Automation, at IRIS, Stavanger, 24 May.

Cayeux, E., Daireaux, B., Mihai, R. 2016. "Automatic Risk Uncertainty Estimation to Support Decission Making during Drilling Operation Planning: Case Study on an ERD Well". Celle Drilling Conference, Celle, Germany, September 12-13.

Cayeux, E., 2017. "Model-driven Drilling Process Automation: Design Considerations and Results from Drilling 17 Sections in the North Sea". SPE Workshop: The Great Drilling Automation Debate, April 19-20. Invited speaker.

Cayeux, E., 2017. "Insights Into the Physical Phenomena That Influence Automatic Gain Loss Detection During Drilling Operations". SPE Webinar Petroleum

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

Flornes, K. 2015. "Innovations for cost reduction". NPF Stavanger.

Flornes, K. 2016. "P&A R&D". Presented at Stortinget, February.

Gardner, D. 2016. "DrillWell P&A projects". Presented at the DEA meeting, St. Andrews, Scotland, 15-16 September.

Gardner, D. 2016. "Ongoing P&A Research in DrillWell". Presented at the NorTex Data Science Cluster Workshop: Plug & Abandonment, OTC, Houston, 5 May.

Gardner, D. 2016. "Overview of P&A innovations". Presented at NPF conference: Reservoir & Production Management, Stavanger, November 28-29, 2016.

Gardner, D. 2016. "Test facility for cement evaluation". Presented at The annual DrillWell seminar, Sola Strand Hotel - September 27-28.

Gardner, D., 2016. "Reducing the cost of Well abandonment". Celle Drilling Conference, Celle, Germany, September 12-13.

Gardner, D., 2017. "Cement barrier evaluation lab". SINTEF Conference - Experimental P&A research for the North Sea, March 20-21, Trondheim.

Gjeraldstveit, H., 2016. "Strategi for industristrisamarbeid og innovasjon – erfaringar frå SFI «DrillWell». SFI-forum Norges Forskningsråd, 28 April.

Gravdal, J.E. 2016. "Goals for the NorTex data science cluster – Drilling & Well Technology". Presented at the NorTex Drilling and Well Conference and Workshop: Digitalization and Integrated Operations, OTC, Houston, 2 May.

Gravdal, J.E. 2016. "Virtual arena". Presented at the NorTex Drilling and Well Conference and Workshop: Digitalization and Integrated Operations, OTC, Houston, 2 May.

Grimstad, A.A. 2016. "Gas release from drilling fluid during depressurization". Presented at The annual DrillWell seminar, Sola Strand Hotel - September 27-28.

Hodne, H., 2017. "Synthetic rock barriers, Geopolymers". SINTEF Conference - Experimental P&A research for the North Sea, March 20-21, Trondheim.

Iversen, F. 2015. "Cementing Irregular Wellbore Geometries". Presented at DEA(e) Q1 2015 Network Meeting.

Iversen, F., Mihai, R. 2016. "Automatic fluid measurement and efficiency benefits for drilling automation". Presented at DEA€Europe Meeting Q1 2016, Vlaardingen.

Kullawan, K. 2012. "Decision analysis for deep imaging and geo-steering". Presented at Transatlantic Science Week, Rice University, Houston, USA, 12-16 Nov.

Kullawan, K. 2016. "Decision Analytics for Look-Ahead Decision-Making: Optimize Your Well and Save Your Money". Presented at the SPE/EAGE Geosteering and Well Placement Workshop in Dubai on 8-10 February 2016.

Kullawan, K., Bratvold, R., Bickel, J.E. 2016. "Decision Analytics for Look-Ahead Decision-Making: Optimize Your Well and Save Your Money". SPE/EAGE Geosteering and Well Placement Workshop in Dubai on 8-10 February.

Lothe, A.E., 2017. "Uncertainty in pore-pressure and mud-weight prediction ahead of bit". Presented at The annual DrillWell seminar, Sola Strand Hotel - September 26-27.

Lund, B., 2016. "Results from displacement experiments in irregular annulus geometries". Presented at The annual DrillWell seminar, Sola Strand Hotel - September 27-28.

Moeinikia, F., Saasen, A., Raksagati, S., Fjelde, K.K., Vrålstad, T. 2013. "Cost effective P&A Approach for Wellhead Removal in Offshore Exploration Wells and Methodology for Comparing Alternatives". Presented at the SPE One Day Seminar, Bergen, April 10.

Paglia, J., Eidvik, J. 2017. "Statistical modeling for online pore-pressure prediction and drilling window". Poster at The annual DrillWell seminar, Sola Strand Hotel - September 26-27.

Stokka, S. 2012. "Centre for Drilling and Wells for Improved Recovery". Presented at the Transatlantic Science Week, Rice University, Houston, USA, 12-16 Nov.

Stokka, S. 2013. "Centre for drilling and wells for improved recovery". Presented at the Offshore Technology Day, Stavanger, October 23.

Stokka, S. 2014. "Cost effective wells for improved oil recovery". Presented at ONS Centre Court, Joining forces to recover more, 26 August.

Stokka, S. 2014. "Drilling and Wells for Mature Fields". Presented at the NPF conference: Mature Fields: Business Opportunities and Challenges", Stavanger, 1-2 April.

Stokka, S. 2015. "P&A in DrillWell". Poster presented at the P&A seminar, Sola, Stavanger, October 29.

Stokka, S. 2015. "P&A in DrillWell". Presented at the INTSOK UK – Norway Network meeting regarding decommissioning, Stavanger, May 20.

Stokka, S. 2015. "P&A, fast and with low cost. P&A in DrillWell". Presented at NPF Stavanger, April 21.

Stokka, S., 2017. "Can tubing be left in hole?". SINTEF Conference - Experimental P&A research for the North Sea, March 20-21, Trondheim.

Suter, E., Helset, H.M. 2012. "The role of automation in improved decision support for optimal well placement". Presented at the "Autonomy in the oil and gas industry" conference, Sola Strand hotel, Norway, 7-8 March.

Suter, E., Kårstad, T., Escalona, A. and Vefring, E.H. 2016. "Decision Support For Proactive Geosteering Under Uncertainty". SPE/EAGE Geosteering and Well Placement Workshop in Dubai on 8-10 February.

Suter, E.C. 2016. "Decision Support for Proactive Geosteering Under Uncertainty". Poster at the SPE/EAGE Geosteering and Well Placement Workshop in Dubai on 8-10 February.

Suter, E.C. 2016. "Decision Support for Proactive Geosteering Under Uncertainty". Presented at the SPE/EAGE Geosteering and Well Placement Workshop in Dubai on 8-10 February.

Suter, E.C., Kårstad, T., Escalona, A., Vefring, E.H. 2016. "A method for locally adaptive gridding and local updates of the geological structure in earth models". Poster presented at the IOR Norway 2016 conference, Recover for the future, Stavanger, 27-28 April.

Suter, E., Alayev, S., Luo, X., Romdhane, A., Eliasson, P., Vefring, E.H. 2017. "Proactive geosteering workflow for enhanced oil recovery". poster presented at the 17th Geilo Winter School: Machine learning, deep learning, and data analytics, January 15-20, Geilo, Norway.

Suter, E., Alayev, S., Daireuax, B. 2017. "RT-Hub: next generation real-time data aggregation while drilling". Poster presentation at EAGE Workshop on Pore Pressure Prediction, March 19-21, Pau, France.

Vrålstad, T. 2014. "Cement sheath integrity during thermal cycling". SPE-173871-MS presented at DEA Dec. 5.

Vrålstad, T. 2014. "Thermal cycling of cement". Presented at SPE Forum on Zonal isolation in Portugal, February.

Vrålstad, T. 2014. "Thermal cycling of cement". Presented at SPE Workshop on Cementing in Lyon, March.

Vrålstad, T. 2014. ''Thermal cycling of cement''. Presented at Well Integrity Forum, Sandnes, June 12.

Vrålstad, T., 2017. ''What is the sealing ability of plugs?''. SINTEF Conference - Experimental P&A research for the North Sea, March 20-21, Trondheim.

Zhou, J., Gravdal J.E., Strand, P., Hovland, S. 2014. ''Automatic Well Control Procedure for Kick Handling in Managed Pressure Drilling Operations Using PWD Data''. Presented at the IADC Well Control Europe Conference and Exhibition, Aberdeen, December 2-3.

Ølberg, T. 2011. ''Senter for Boring og Brønn for økt Utvinning (SBBU) - et verktøy for innovasjon og bidrag innen sikkerhet, verdiskaping og effektivitet''. Presented at the NPF drilling and well conference, Kristiansand, September.

MEDIA

Adjacent Oil and Gas Journal, Technology and Innovation 2015. ''Model based drilling software'', November Edition.

Adjacent Oil and Gas Journal, Technology and Innovation 2016. ''Realistic simulator tools are crucial to reduce drilling costs'', October Edition.

Aftenposten 2013. ''Eldrebølgen på norsk sokkel'', November.

Drilling Contractor, Interview with Jing Zhou 2014. ''Case study: Automatic kick control reduces kick size, time to establish control of well'', December edition.

Norsk Sokkel, Oljedirektoratet, Interview with Sigmund Stokka 2015. ''Når gode fat blir dyre'', January 6.

NRK Rogaland, Interview with Sigmund Stokka 2014. ''Kostnadene på norsk sokkel'', October 9.

Nyheter fra Oljedirektoratet 2016. ''De nominerte til Beste stand på ONS 2016'', September.

OilField Technology Magazine, 2017. ''Advancements in Automation'', February, page 29-30.

Pan European Networks: Science & Technology, Issue 12 2014. ''Profile: The DrillWell Centre'', September.

SPE Web Events, Webinar, 2017. ''Estimation of Risk Level Embedded in Drilling Operation Plans'', June 15.

Stavanger Aftenblad 2011. ''Stavangers første prestisjesenter'', September

Stavanger Aftenblad 2013. ''7000 milliarder kroner mer til Norge med bedre teknologi'', October.

Stavanger Aftenblad, Interview with Kristin Flornes 2015. ''Alt er ikke svart – lavere oljepris og omstilling gir også muligheter''.

Teknisk Ukeblad 2010. ''Boresenter vil øke sikkerheten'', December.

Teknisk Ukeblad, Interview with Harald Linga and Sigmund Stokka. ''Et «kick» i brønnen kan bli katastrofe. Nå tror norske forskere de har funnet en løsning'', November 2015.

Teknisk Ukeblad, Interview with Kristin Flornes 2015. ''Oppsagt oljeingeniør med god ide? Dette bør du satse på. Eksperttips fra bransjen''.

Upstream Online 2016. ''Slender advantage in well tech'', February 19.

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.

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