Issue 10
September 2016

Norway Council
www.spe.no

The First

SPE Norway magazine

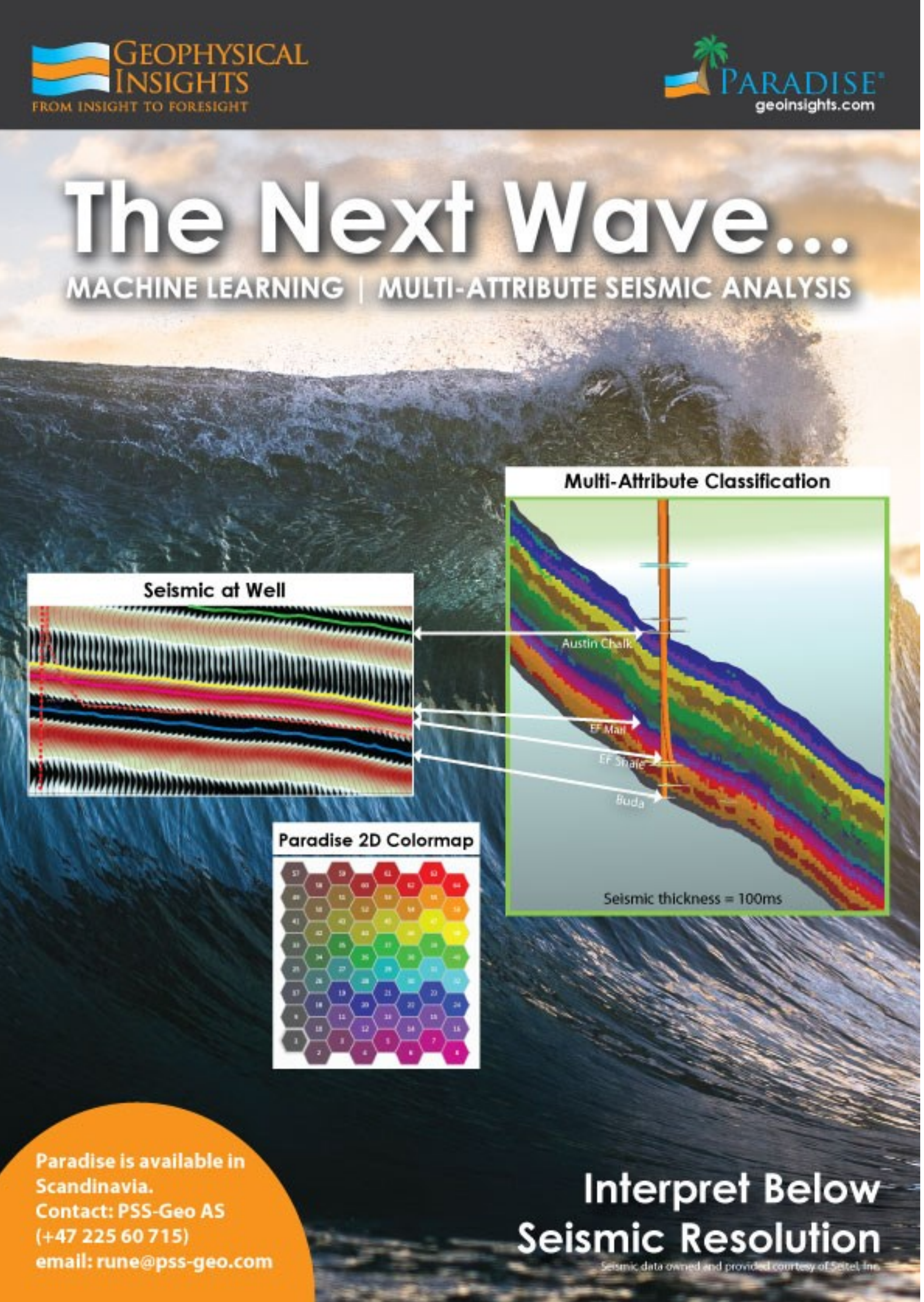
To gather members
To share knowledge

Gullfaks 4D — Matching pressure and production history

Paper abstracts by our members

New Horizons — Iran welcoming the Norwegian companies

Picture: Mojtaba Seddigh Arabani, the Head of Seismic Data Interpretation, Geophysics Department, NIOC



Would you like to join the editorial team of "The First" magazine? Contact Maria/Vita or your local Section.

Follow SPE Norway sections in social media:

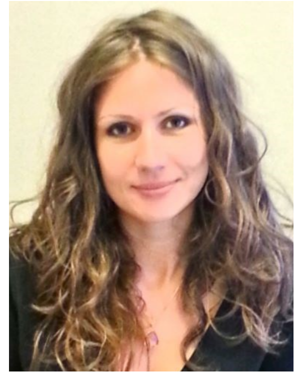
SPE Oslo
SPE Stavanger
SPE Bergen
SPE Northern Norway
SPE Trondheim

Dear "The First "Readers,

The new 2016-2017 SPE Norway season has started. A lot has happened in the past season and despite of the continuous low oil prices, our optimism is still high.
We are here to tell you about exciting SPE programmes over Norway, to share experts' experiences and just to inform you about interesting stories in the Oil&Gas from all over the world.
We are very excited that SPE President is contributing to our magazine. D. Nathan Meehan tells us about SPE today and his Norwegian connections. Thank you for this! We would like to thank all of the authors for sharing their experience with SPE Norway.
Two of our sections received awards — SPE Oslo 2016 President's Award for Section Excellence and SPE Northern Norway 2016 SPE Gold Standard. Congratulations!!!
We wish all sections, SPE members and followers a pleasant and productive 2016-2017 season!
Enjoy your reading and don't forget to send us feedback!

On behalf of "The First" editorial team,
Vita Kalashnikova

Vita Kalashnikova
Editor "The First"/ QI Geophysicist, PSS-GEO AS



Maria Djomina
Editor The First / Communications Manager, AGR

The First is SPE Norway Regional publication and is distributed to a multidiscipline audience. Circulation: 200 printed copies, 4,500 electronic copies

The editorial team takes no responsibility for accuracy or content of the articles provided. Technical articles, professional overviews and SPE section news have no editorial fee.

If you would like to support production of our magazine by publishing commercial information about your product/company, please contact editorial team.

Editors:
Vita V Kalashnikova
vita@pss-geo.com
Maria Djomina
Maria.Djomina@agr.com

The editors are working on voluntary basis.

The electronic version of this Issue and previous Issues are available on SPE Norway websites.

Editorial content

Technical articles

SPE President—D. Nathan Meehan

D. Nathan Meehan

Senior Executive Advisor and
2016 SPE President
Baker Hughes
nathan.meehan@bakerhughes.com

First, I wish to extend my greetings and thanks to SPE members in Norway for their wonderful contributions to the society, to our industry and to my family personally. Today the SPE Board of Directors holds three annual meetings. One is conducted at the fall meeting while the other two are often held outside the U.S. This was not always the case, and when I served on the board we conducted our first board meeting outside of North America in Stavanger.

Norwegian contributions to advanced technology have been globally noted along with impact reservoir development, drilling and production activities. Personally, Norway has been home to my second daughter, her husband (a drilling engineer) and four of my grandsons, one of whom was born in Norway. I think these boys could pass for Norwegian, but I will leave that to you to decide. We have grown to eat our waffles with sour cream and jam or occasionally with brown cheese!

Their Norwegian neighbours and co-workers have welcomed them with open arms, and my wife and I have made many visits to Norway over the past five years. I haven't learned much Norwegian during these visits but I will say "tusen takk" to all of you.

Norway is a country with a big emphasis on environmental and sustainable programmes. Electricity generation is largely from hydroelectric power plants, a renewable resource that cannot be widely replicated. Globally, hydropower as a fuel source is expected by some to remain approximately constant (Figure 1). Technically available hydropower is approximately 100% of the current world production; however, the environmental impact of the many new dam projects required to access such resources makes it almost impossible to develop these opportunities. Many environmental groups are "more" opposed to new hydro projects than to new nuclear projects. I am not optimistic about hydropower's growth and do not think hydropower will significantly increase its absolute contributions to world energy supply and, therefore, will decrease in its relative contribution.

We are all concerned about environmental and climate change issues. Norway has unilaterally addressed greenhouse[1] gas emissions with sector-specific carbon taxes covering about 70% of the country's GHGs. While meant to be compatible with EU schemes, Norway's programme has been reasonably successful. The EU cap and trade system had good intentions but was rife with fraud, resulting in many billions of Euros being stolen. Future viability of any widespread carbon pricing scheme has to address many issues that are quite difficult. For example, manufacturing economies that implement a price on carbon but do not tax the energy content of imported goods run the risk of exporting their manufacturing capacity and jobs to economies with lower environmental standards. This could result in no net improvement (and perhaps an increase) in emissions.

SPE doesn't have a position on climate change, but we do have one on sustainability. We are working on the issue of climate change to identify the correct strategy for the society. I am confidant SPE *will not* take a position on carbon pricing, taxes, etc. Our expertise is not in climatology and climate modeling; therefore, SPE won't take a position on the validity of models and predictions for climate change. While many SPE members strongly support efforts to reduce GHGs, some SPE members doubt the conclusions of climate models while others are skeptical of steps proposed to reduce climate change's negative impacts.

We will, however, provide a place for technical discussions on climate change issues within the scope of our mission including CO_2 capture and storage, improved efficiency, reducing fugitive methane emissions, venting and flaring, improving wellbore integrity, monitoring wellbore and caprock integrity, using CO_2 for enhanced oil recovery, using natural gas as a lower carbon fuel, etc.

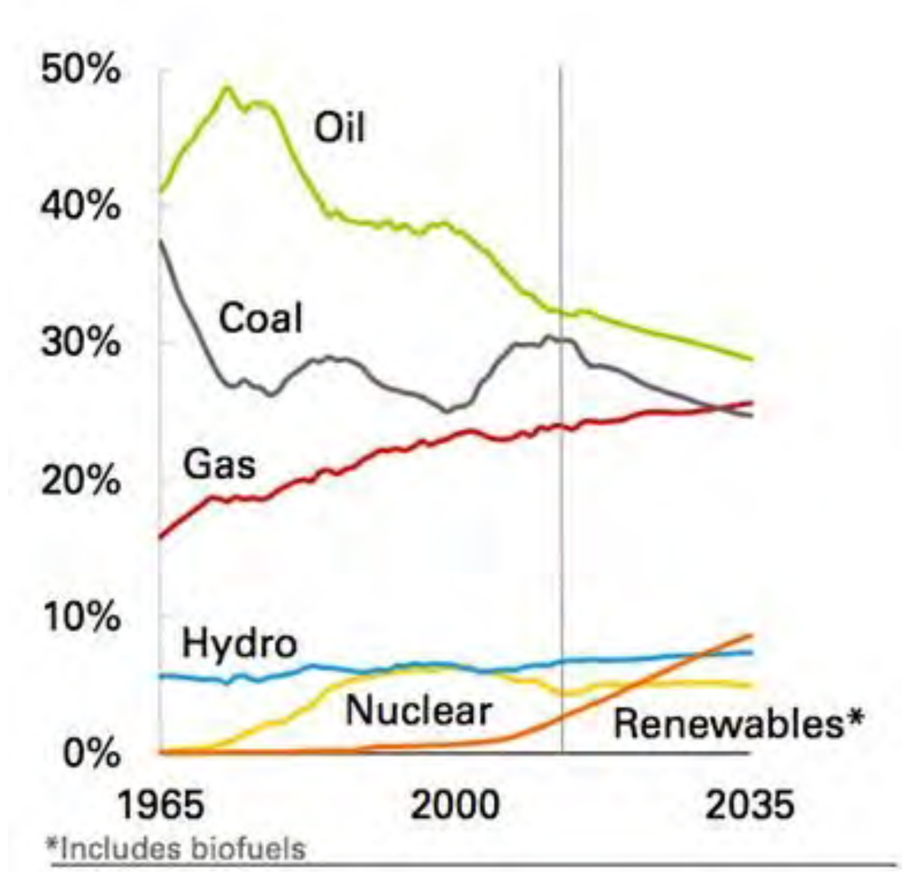


Fig 1: From BP Energy Outlook 2016

There are many definitions of sustainability, but the 1987 United Nations Brundtland Commission remains a standard: *"meeting the needs of today without compromising the ability of future generations to meet their own needs."*[2]

Some think oil and gas have little role in a sustainable future; global realities suggest otherwise. How is it that a finite energy resource and a source of greenhouse gas emissions can be part of a sustainable future? Oil and gas are essential to meeting the "needs of today;" their prudent use is the safest way to ensure that we do not compromise the "ability of future generations to meet their own needs."

SPE has its own sustainability definition as follows:

> *"Exploration, development and production of oil and gas resources provide affordable energy that contributes significantly to well-being and prosperity.*
>
> *SPE encourages the responsible management of these oil and gas resources and operations including the appropriate management of social and environmental impacts and their related risks.*
>
> *SPE demonstrates this commitment by offering its members opportunities to train, share knowledge and advance practices for doing business in ways that balance economic growth, social development and environmental protection to meet societal needs today and in the future."*
>
> *— Approved by the SPE Board of Directors, May 2014*

Petrowiki has an excellent discussion of sustainability at http://petrowiki.org/Sustainability including references to

[1] Carbon Dioxide (CO_2), Nitrous Oxide (N_2O), Perfluorocarbons (PFCs)
[2] World Commission on Environment and Development (WCED). *Our common future.* Oxford: Oxford University Press, 1987 p. 43

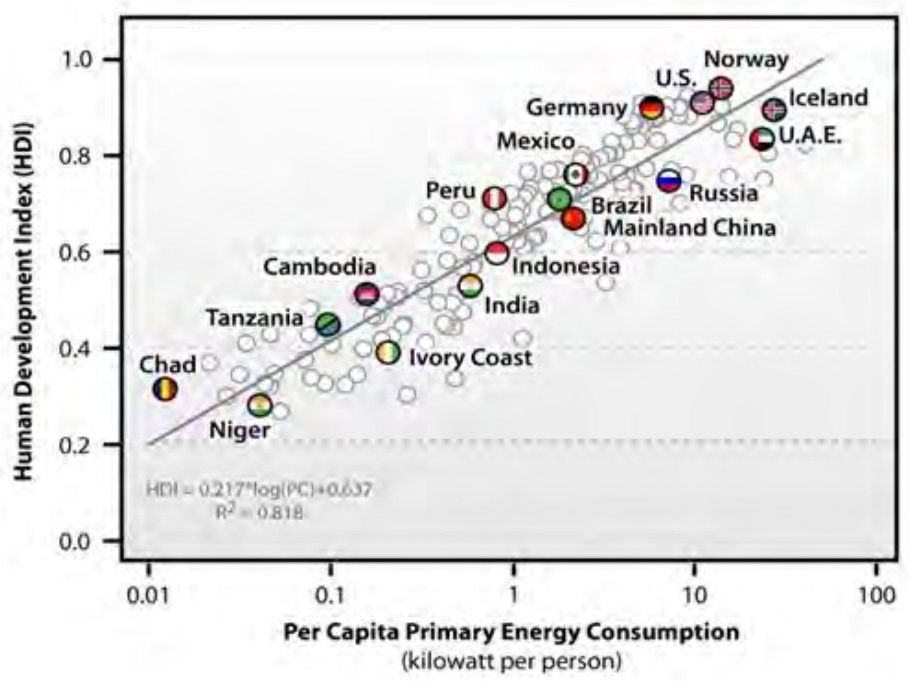


Fig 2: Source: Energy, the Wealth of Nations, and Human Development: Why We Must Have Renewable Fuels,"Bruce E. Dale, presented at Sustainable Energy for Sustainable Development

noteworthy papers in OnePetro.org.

Safe, affordable energy is central to quality of life. For example, it is essential for farmers to be able to produce sufficient food and transport it to consumers. Affordable energy also is essential for housing, heating and cooling, clothing and all other necessities of life. Quality of life is strongly correlated to energy usage.

The Human Development Index (HDI) is a statistical tool developed by the United Nations to measure and rank countries' levels of social and economic development based on: Life expectancy at birth, average and expected years of schooling and gross national income per capita. HDI is strongly correlated to energy use. No countries have both a high HDI and low energy use.

Supplying the energy for the world is a monumental task, and we continue to see improvements in renewable energy sources. However, reasonable forecasts of growth in renewables suggests fossil fuels will remain the primary source of the world's energy for decades to come. Only radical growth in nuclear power could seriously diminish this result. Real world realities reflecting public concerns over nuclear safety and concerns over the proliferation of radioactive materials make such growth unlikely.

While coal resources are abundant, concerns over greenhouse gas emissions and the possibilities of pricing carbon through taxes, caps, exchanges or other mechanisms and the relatively low cost of natural gas continues to make natural gas a more attractive fuel. This is true whether you expect it to be a relatively near-term "bridge fuel" to a renewable future or (as I do) part of our longer-term energy solutions.

If oil and gas are to be part of a sustainable solution to our energy needs, there are some things we can and should do better as petroleum engineers. These include:

♦*Minimize methane emissions*: Leaks and incidental releases of methane are important to reduce or eliminate since methane has (pound-for-pound) a 25 times greater impact on climate change than does CO_2[3].Natural gas and petroleum systems account for 29% of all U.S.

[3] http://www3.epa.gov/climatechange/ghgemissions/gases/ch4.html
[4] http://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Chapter-3-Energy.pdf

methane emissions. Domestic livestock and associate manure management account for 36%. Landfills and coal mining combine for another 28%. In total, CH_4 accounts for 10% of U.S. greenhouse gas emissions.

Methane emissions associated with natural gas and petroleum systems have declined significantly from 1990 in spite of substantial increases in natural gas production and widespread growth on pipelines and processing facilities[4].

We must continue this progress and eliminate fugitive emissions of methane associated with oil and gas production, transportation and processing. There will be a role for drones and other technologies to improve monitoring and early detection capabilities.

♦*Reduce or eliminate flaring*: Flaring should be infrequent, temporary and efficient. Technologies to make flaring highly efficient are available and represent best current practices. Long-term flaring of volumes of gas that cannot be (easily) sold needs to be eliminated globally. This goal may require commitments to gas reinjection, local use, local power generation, local CNG manufacturing, etc. Regulators need to set aggressive but technically achievable standards and timetables. They should start to eliminate the largest problems first and use a balanced approach. Operators need to develop fields with this goal in mind.

Unconventional (tight oil) operators in areas without low-pressure gathering systems will need to develop many-well drilling pads enabling sufficient volumes of natural gas to be used locally or otherwise exploited. In such cases, gas represents a secondary product and regulatory and taxing bodies should preferentially treat developments that utilize semi-commercial volumes of gas rather than flaring such volumes.

♦*Energy efficiency and conservation*: We support energy efficiency measures. Such measures make the most sense when they have a reasonable economic benefit. The current price environment makes it more difficult to justify such measures, whether they involve a homeowner installing additional insulation or an airline purchasing more fuel-efficient airplanes. Government subsidies of such efficiency improvement measures may make sense when wide spread adoption of a marginally commercial solution will lead to cost reductions or significant improvements in the required technologies.

Conservation measures imply a change in consumer behavior rather than just an improvement in efficiency. Once again, the current product price environment is less likely to encourage conservation efforts whether it is in transportation, recreation or other decisions. Government actions mandating conservation efforts may be viewed as heavy handed. The "carrot" approach is more likely to achieve results than the "stick."

♦*Wellbore integrity*: Wells are completed with casing, liners and cement whose primary purpose is to prevent fluid migration from one zone to another. Such integrity is vital to minimizing the likelihood that hydrocarbons or salt water might migrate behind pipe and contaminate other formations. Casing collapse, casing leaks, inadequate primary cementing or deterioration of cement all must be avoided and technologies implemented to ensure wellbore integrity. Cement job design including spacers, quality control during implementation and long-term monitoring ensure that desired fluids are produced and that all other fluids stay in place. Advances in fiber optic monitoring technology such as Distributed Acoustic Sensing may be useful for monitoring critical wells.

♦*Reducing surface footprint*: When many wells need to be drilled, drilling from a central wellpad or cluster reduces surface footprint, minimizes transportation disruptions, allows produced or flowback water to be used more effectively, allows shared use of production facilities, allows commercial use of small volumes of gas, is easier to operate and has many other benefits.

Many unconventional wells are subcommercial even if the combined results of all wells drilled is economic. Many individual hydraulic fracture stages appear to not contribute measurably to flow. Engineers collaborating with earth scientists, petrophysicists, geomechanics professionals, service providers and others to eliminate the need for unnecessary stages or wells improve economic returns, lower the demand for water and minimize all other environmental impacts on production.

SPE Norway — A Note from the President

♦*Eliminate spills*: Whether a surface spill during oilfield operations or a catastrophic blowout, consistent planning, use of best available technology and flawless execution are keys to eliminating spills. Eliminating small spills is good business. Eliminating large spills may mean staying in business. As I mentioned in a previous column on safety, our company considers spilling small volumes enough to ruin the entire "Perfect HSE Day" that we strive for. Blowout control eliminates spills and saves lives.

♦*Optimize field development and management*: An asset team working on simulating reservoir performance and designing an optimized plan may not think of their work as contributing to sustainability. But the reality is that almost everything we do as petroleum engineers contributes to sustainability. Can we recover the most barrels with fewer wells? Can we invert that waterflood injection pattern and lower total fluid handling requirements? Can our well monitoring plans identify damaged wells early and allow them to operate at maximum efficiency?

As we drill, complete, equip and produce wells more efficiently, we are further contributing to sustainability.

We make it possible to meet the world's needs today and improve people's lives by providing safe, affordable energy. The more efficient we are, the more affordable that energy becomes.

The IPIECA/API/OGP developed oil and gas industry reporting standards for environmental indicators, health and safety indicators and social and economic indicators. Environmental indicators include greenhouse gas emissions, measures of energy efficiency and usage, gas flaring, biodiversity and ecosystem impacts, alternative energy use, spills and waste. HSE indicators proposed were relatively standard. Social and economic indicators included local and community impacts, indigenous people impacts (including involuntary resettlements), social and community investments (including jobs, training and local sourcing), security and human rights, corruption issues at various levels and workforce diversity issues.

Many companies voluntarily report their results[5], and similar measures of sustainability are in place for service companies and others. The real measure of our role in sustainability remains our individual commitments to doing the right job and getting that job done right.

As I travel throughout the world, I am more convinced than ever that we -- as an industry and as SPE members in particular -- are committed to improving today's quality of life but not at the expense of generations to come.

[5] http://www.ipieca.org/focus-area/reporting

SPE Norway — News from Oslo section

Lessons Learned, How NOT To Do Drilling Automation

The season in Oslo was kicked off by a network and dinner meeting at the Continental hotel in Oslo centrum with an interesting presentation from dr William Koederitz.

Abstract

The uses of automation in drilling are expanding and typically resulting in improved performance. However, many of these projects struggle in the initial stages, often trying to overcome a common set of hurdles. Many of these hurdles are not technical challenges, but involve people issues and the implementation methods.

Dr. Koederitz' presentation covered the basics of drilling automation and described the problems and solutions that have been found to improve the startup success for drilling automation.

The idea to take away: For automation to be successful, the key users, especially the driller, must be involved in every step of design and implementation.

Bill Koederitz is chief technology officer at GK Plus Innovations. Previously, Koederitz spent 20 years building real-time applications and drilling automation systems at National Oilwell Varco. Koederitz holds BS, MS, and PhD degrees in petroleum engineering from Louisiana State University and is a registered petroleum engineer in Texas. He has authored or coauthored 25 technical papers and holds 15 patents.

ConocoPhillips presenting to Student Chapter

By Fredrik Wesenlund

The SPE Oslo Student Chapter had the pleasure of hosting ConocoPhillips at the University of Oslo in early September. The Student Chapter and ConocoPhillips have a long tradition of cooperation, demonstrated by the current event. The event started with the President of the SPE Oslo Student Chapter, Thea Faleide, introducing the audience regarding SPE's overall goal, which essentially is to enhance the technical and professional competence of the SPE Student members.

Following the SPE presentation, ConocoPhillips HR advisor, Tore Mjølsnes, introduced ConocoPhillips as a leading energy company on the NCS and abroad. ConocoPhillips is situated in 21 countries, with over 15,600 people around the globe working on finding and producing oil and gas. As such, ConocoPhillips have an important role in terms of energy production, both in Norway and globally.

Two Young Professionals hired within ConocoPhillips elaborated on their education and interests prior to working for ConocoPhillips, as well as their development within the company. The average student may think that a career within the energy industry seem daunting, especially considering the current job market in Norway. However, these Young Professionals are living proof that, if you work hard, it is still possible to work as an energy professional.

Rune Tveit continued by talking about job opportunities within ConocoPhillips for recent graduates and students. Of particular interest was the ability to work with real life challenges as part of ConocoPhillips' summer internships. This included e.g. well placement decisions and seismic interpretation, among other tasks.

The company presentation rounded off with delicious pizza and soft drinks. The audience were eager to know more about the company and ConocoPhillips representatives were happy to answer questions. Conclusively, the tradition of SPE Oslo Student Chapter and ConocoPhillips cooperating was, once again, successful.

SPE Bergen One Day Seminar 2017 – Call for Papers Now Open!

We invite you to share your expertise by submitting your paper proposal by 31 October.

1. Reservoir
2. Completion
3. Well Intervention
4. Production and operation
5. Drilling
6. Digital oilfield and drilling
7. Petrophysics
8. HSE and Quality work processes
9. New energy resources

Paper Proposal Submittal Guidelines

1. Obtain the necessary clearance from your management.
2. The paper proposal must be a minimum of 200 words and no more than 300 words in length and should include a description of the proposed paper, results/conclusions, and the technical category most applicable to your paper.
3. The paper proposal must be received by **31 October 2016**
4. Submit your paper proposals online. This website also offers guidelines for preparing and submitting your paper proposal on time.
5. Do not include the title or author names in the body of the abstract. The title and author information will be requested separately through the submission system.
6. Please note that, if accepted, your paper proposal may be published, as submitted, in conference information media, including on the SPE website.
7. Authors whose paper proposals are accepted will be required to provide a manuscript for inclusion in the conference Proceedings. Authors who do not submit a manuscript and the associated publication forms by the manuscript due date will be withdrawn from the programme and will not be allowed to present. The programme committee will review draft manuscripts before the final versions are submitted to SPE for publication. Manuscripts will be due to SPE no later than **6 February 2017**.
8. For more information visit SPE Bergen website.

The First

SPE Norway — News from Stavanger section

The season in Stavanger was kicked off by a meeting on September 20th where more than 70 people attended to listen to John Machpherson of Baker Hughes discussing Automation of the Drilling System at Scandic Stavanger City Hotel.

Tor Jørgen Verås
SPE Stavanger Web Chair
Tel: +47 48290938
tj.veraas@halliburton.com

Tech-Nights

Save the date for monthly technical meetings:

October 18th
November 9th
December 7th

MOVIES WITH SPE STAVANGER

SPE Stavanger is inviting members and sponsors to the world premiere of the Deepwater Horizon movie. Prior to the movie start, there will be introductory speeches given by Sigve Knudsen, Director of Legal and Regulatory Affairs at PTIL, and Bjørn Holst, Vice President of Corporate Safety at Statoil.

September 30th, 7 PM
Stavanger Kino

Iran is welcoming Norwegian companies

by Vita Kalashnikova

Tehran, Iran

After lifting the sanctions against Iran on the 16th of January 2016, the Iranian market was opened for foreign companies. The government of Iran have been developing a new model of licenses and contracts to attract foreign companies to work and investment. Oil and Gas companies have been signing "old" and new agreements and on 17th August, Norway signed a cooperation agreement for increasing trade.

Iran is the fourth largest oil reserves holder in the world and it can provide a lot of work for the regional service companies. Nevertheless, the service companies have not been that proactive. There are still some issues including software and equipment that moves services market slowly.

A number of Norwegian companies have established a new foothold in Iran, and have formed a formal and informal alliances with Iranian partners. We'll report on the visit of one company who has partnered with Mehran Engineering and Well Services, the largest privately owned Iranian oil services company.

The First Geo AS with subcontractors visited recently Mehran and National Iranian Oil Company (NIOC) Exploration department, where pilot studies were performed and new technologies demonstrated.

The colleagues at NIOC were very helpful and proud of their country showing around at the office, city and famous bazaars. Ivar Meisingset, Exploration Services Manager at First Geo, the lead of the delegation, tells, "My first trip to Iran was in May, to participate in the Iran Oil Show together with my friend and colleague Per Haugum. Since then I have visited twice with other colleagues, in July and most recently in August/September when we carried out a series of studies for NIOC Exploration Directorate. I have been quite impressed by the Iranian society and the

Kebabs, traditional Persian food
If you are in Iran, you should definitely try Beluga Kebab, Caspian Sea fish

people I have met. They are well educated, and there are many women in high technical positions. Their tradition is to treat guests well, we have been met with a level of hospitality which exceeds by far what we are used to at home. On the technical level we have been met by highly experienced and competent people, but there is a margin of technology and practical know-how where the Iranians have been falling a little bit behind during the years of sanction. They now are eager to catch up, that is why we and others like us are welcomed to Iran these days."

Ivar Meisingset (left) and Per Haugum (right) together with International Affairs Manager Reza Morovatdar in the Iran Oil Shown in May 2016

Road to Success: Establishing Iranian Norwegian JV in Iran Upstream Oil Industry

Mehran has been active in the oil and gas upstream industry since 2000 and through working with the biggest Iranian clients has secured a total contract value of about one bio USD. This fact along with their unique engineering team has made Mehran the biggest private drilling services company in Iran.

Alireza Safari, International Affairs Engineering Coordinator, shares Mehran's vision for the Norwegian collaboration with *The First,* "Mehran offers a wide variety of offshore/onshore drilling and well services within Cementing, Stimulation/Acid Fracturing, Coiled Tubing, Well Testing & DST, Pumping & N2 Lifting, Slickline, Wellhead & Completion, H2S Safety, Directional Drilling & Surveying, and Integrated Drilling Services as its in-house services. Mehran has also provided many other drilling and well services as its outsourced services to the clients.

Taking into account that international sanctions against Iran have been lifted, developing our capabilities is our primary priority. We have established JVs with prestigious companies in different disciplines. In order to demonstrate the Iranian-Norwegian capabilities, negotiations started with different entities of NIOC and led to holding some technical workshops, pilot studies, and case study proposals. The output has been extremely pleasant for these clients and Mehran-First Geo JV has been invited to some upcoming tenders.

After some visits by First Geo team from Mehran office and also Iran Oil Exhibition 2016, and in order to extent area of cooperation and have a better insight from Norwegian partner, a group of Mehran's top managers from different expertise visited Norway and also attended ONS-2016 in Stavanger from 29-August to 1-September."

Exploration Directorate, NIOC, Tehran, Iran

Inside of NIOC

NIOC, with a vast amount of oil and gas resources, is one of the world's largest oil companies. At the present time, it is estimated that the company holds 156.53 billion barrels of liquid hydrocarbons and 33.79 trillion cubic meters of natural gas.

NIOC Exploration Directorate shares sever floors in a modern building in Northern Tehran. Close collaboration and interactive discussions are usual working process here.

Usually, burning discussions are compromised over a cup of tea. A moment of daily working culture which hopefully could also be implemented in Norway:). Seems like the Iranians win the tea drinking race over the English.

The ceremony itself is beautiful. A person who comes to invite others with his beautiful cup of freshly made tea is important reminding that one should take a break.

Delicious fresh made tea in NIOC office, service for employees

Once again tea time (Mehran offices). Gorgeous cups, aromatic tea – that is pleasant difference of business in Iran.
Ivar Meisingset (left) and Astri Rørnes (right), First Geo

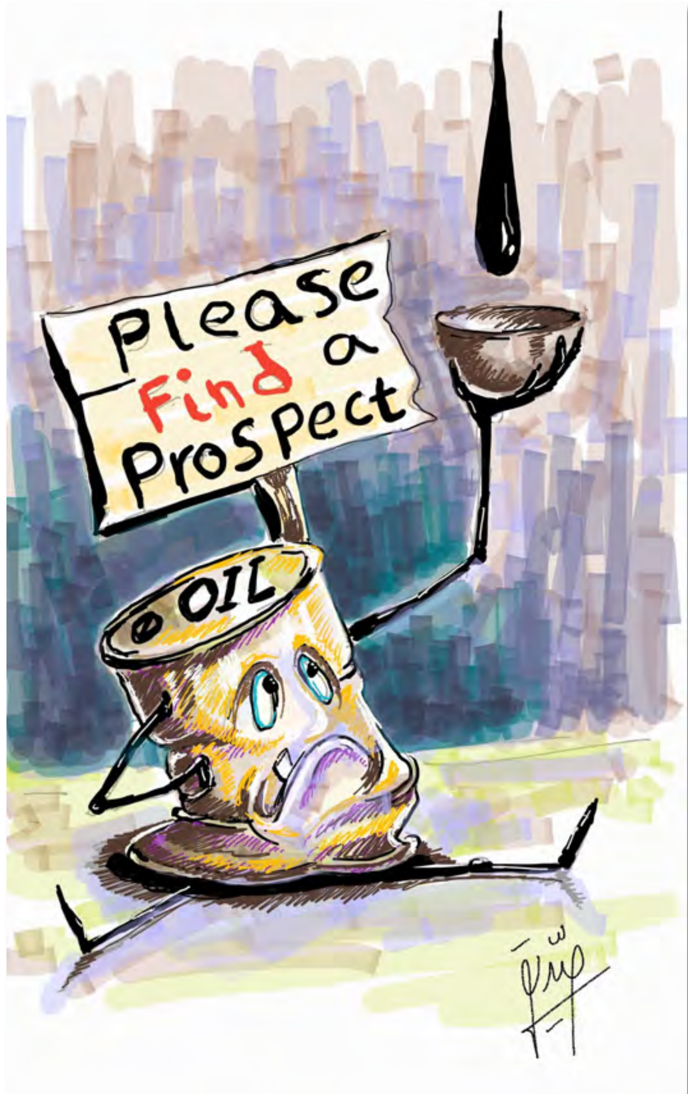
Meet geoscientist and an artist - Mojtaba Seddigh Arabani, heading the Seismic Data Interpretation in Geophysics Department at NIOC. Mojtaba has been working at NIOC-Exploration Directorate since 2002. He is also an artist who enjoys drawing and painting.

"Caricatures are my most favorite thing to compose combining contents and virtual elements especially about the Oil and Gas industry, which is my job", said Mojtaba.

In fact, the combination of expert geoscientist, artist and unique personality makes him a personality generating exciting and wonderful artistic effects.

"My caricatures try to say some facts from a funny aspect and to relate with the viewers in a simple way.''

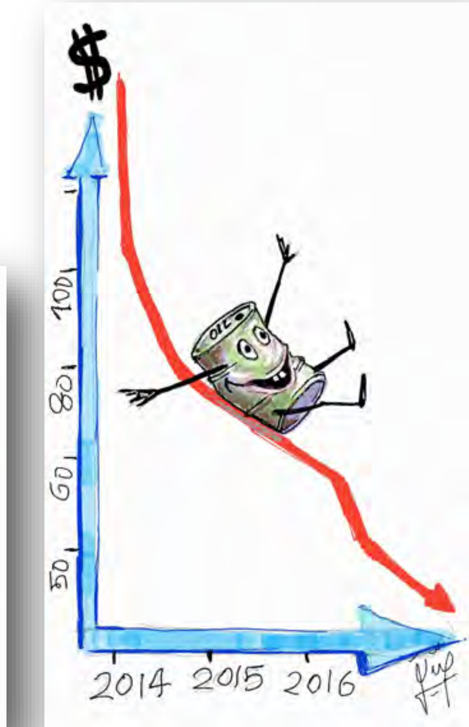
The First is very glad to introduced Mojtaba's work in our magazine with his permission.

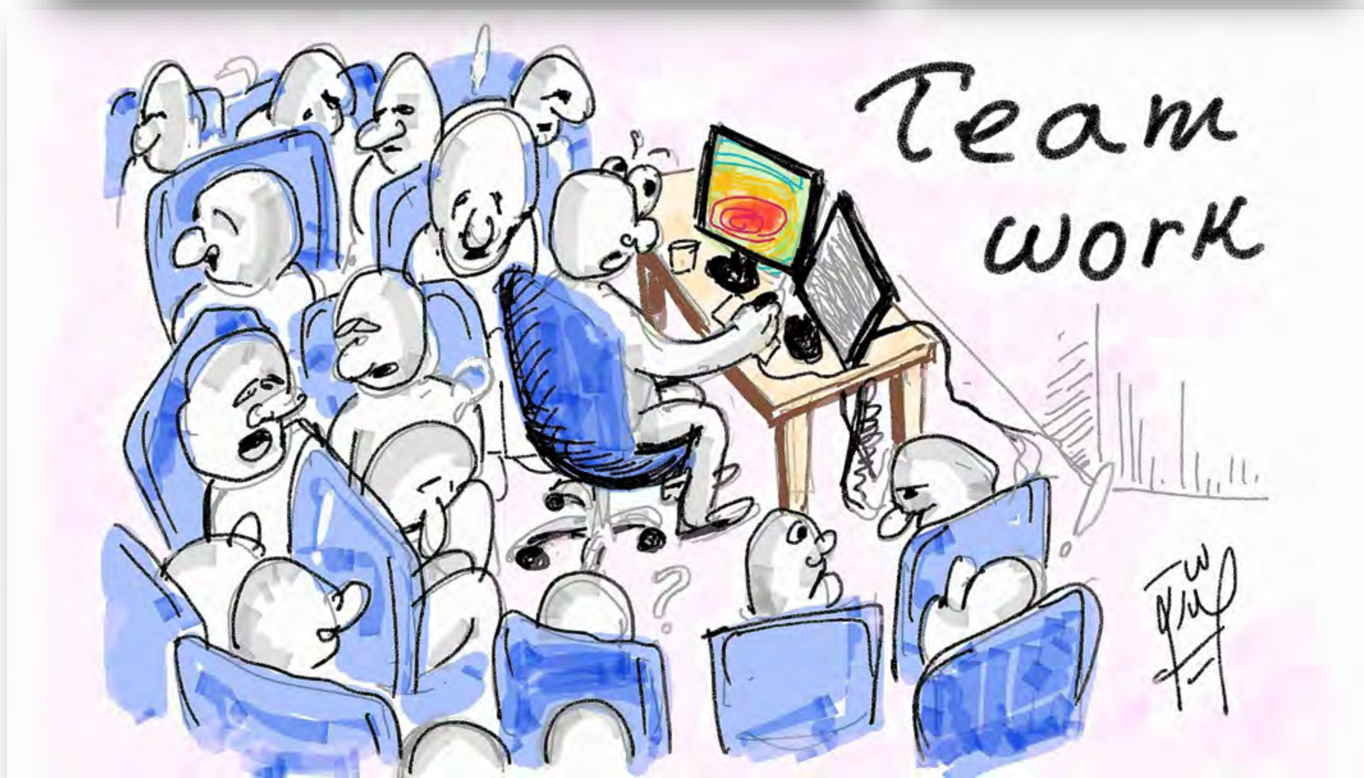


Ivar Meisingset, First Geo (left) and Mojtaba Seddigh Arabani, NIOC (right)

Mojtaba Seddigh Arabani
the Head of Seismic Data Interpretation in Geophysics

Mojtaba Seddigh Arabani Art.
Feel free to put on the wall of your office! =)





The First

Oil Discoveries at a 70-Year low signal a supply shortfall ahead

by Mikael Holter, Bloomberg

Mikael Holter
Bloomberg
mholter2@bloomberg.net

Explorers in 2015 discovered only about a tenth as much oil as they have annually on average since 1960. This year, they'll probably find even less, spurring new fears about their ability to meet future demand.

With oil prices down by more than half since the price collapse two years ago, drillers have cut their exploration budgets to the bone. The result: Just 2.7 billion barrels of new supply was discovered in 2015, the smallest amount since 1947, according to figures from Edinburgh-based consulting firm Wood Mackenzie Ltd. This year, drillers found just 736 million barrels of conventional crude as of the end of last month.

That's a concern for the industry at a time when the U.S. Energy Information Administration estimates that global oil demand will grow from 94.8 million barrels a day this year to 105.3 million barrels in 2026. While the U.S. shale boom could potentially make up the difference, prices locked in below $50 a barrel have undercut any substantial growth there.

New discoveries from conventional drilling, meanwhile, are "at rock bottom," said Nils-Henrik Bjurstroem, a senior project manager at Oslo-based consultant Rystad Energy AS. "There will definitely be a strong impact on oil and gas supply, and especially oil."

Global inventories have been buoyed by full-throttle output from Russia and OPEC. They've flooded the world with oil despite depressed prices as they defend market share. But years of under-investment will be felt as soon as 2025, Bjurstroem said. Producers will replace little more than one in 20 of the barrels consumed this year, he said.

Global spending on exploration, from seismic studies to actual drilling, has been cut to $40 billion this year from about $100 billion in 2014, said Andrew Latham, Wood Mackenzie's vice president for global exploration. Moving ahead, spending is likely to remain at the same level through 2018, he said.

Exploration is easier to scratch than development investments because of shorter supplier-contract commitments. This year, it will make up about 13 percent of the industry's spending, down from as much as 18 percent historically, Latham said.

The result is less drilling, even as the market downturn has driven down the cost of operations. There were 209 wells drilled through August this year, down from 680 in 2015 and 1,167 in 2014, according to Wood Mackenzie. That compares with an annual average of 1,500 in data going back to 1960.

10-Year Effect

Ten years down the line, when the low exploration data being seen now begins to hinder production, it will have a "significant potential to push oil prices up," Bjurstroem said.

"Exploration activity is among the easiest things to regulate, to take up and down," said Statoil ASA Chief Executive Officer Eldar Saetre, in an interview at the ONS Conference in Stavanger, Norway on Monday. "It's not necessarily the right way to think. We need to keep a long-term perspective and maintain exploration activity through downturns as well, and Statoil has."

Oil prices at about $50 a barrel remain at less than half their 2014 peak, as a glut caused by the U.S. shale boom sent prices crashing. When the Organization of Petroleum Exporting Countries decided to continue pumping without limits in a Saudi-led strategy designed to increase its share of the market, U.S. production retreated to a two-year low.

Creating Opportunities

Kristin Faeroevik, managing director for the Norwegian unit of Lundin Petroleum AB, a Stockholm-based driller that's active in Norway, said it will take "five-to-eight years probably before we see the impact" on production from the current cutbacks. In the meantime, he said, "that creates opportunities for some."

Oil companies will need to invest about $1 trillion a year to continue to meet demand, said Ben Van Beurden, the CEO of Royal Dutch Shell Plc, during a panel discussion at the Norway meeting. He sees demand rising by 1 million to 1.5 million barrels a day, with about 5 percent of supply lost to natural

declines every year.

On Monday, oil declined amid doubts producers will agree on a deal to stabilize the market when suppliers meet next month for informal talks. Iran's plan to continue boosting crude output until it regains its pre-sanctions OPEC market share is dimming prospects of collective action, said Patrick Allman-Ward, CEO of Dana Gas PJSC.

Less Risk

Persistently low prices mean that even when explorers invest in finding new resources, they are taking less risk, Bjurstroem said. They are focusing on appraisal wells on already-discovered fields and less on frontier areas such as the Arctic, where drilling and developing any discovery is more expensive. Royal Dutch Shell Plc and Statoil ASA, among the world's biggest oil companies, abandoned exploration in Alaska last year.

"Traditionally, it's the big companies that have had the means to gamble, and they might be the ones that have cut the most," Bjurstroem said.

Overall, the proportion of new oil the industry has added to offset the amount it pumps has dropped from 30 percent in 2013 to a reserve-replacement ratio of just 6 percent this year in terms of conventional resources, which excludes shale oil and gas, Bjurstroem predicted. Exxon Mobil Corp. said in February that it failed to replace at least 100 percent of its production by adding resources with new finds or acquisitions for the first time in 22 years.

"That's a scary thing because, seriously, there is no exploration going on today, " Per Wulff, CEO of the offshore drilling company Seadrill Ltd., said by telephone.

The article was originally published on Bloomberg with assistance from Rakteem Katakey and Mark Shenk.. To contact Mikael Holter, please write at mholter2@bloomberg.net.

The most valuable commodity on Wall Street: Information

by Per Fossan-Waage, Director, PricewaterhouseCoopers

Per Fossan-Waage
per.fossan-waage@no.pwc.com
Director

Wall Street – the movie

The 1987 movie Wall Street tells the story of Bud Fox (Charlie Sheen), a young and impatient stockbroker willing to do anything to get to the top. He gets involved with the corporate raider Gordon Gekko (Michael Douglas), who takes Fox under his wing, and teaches him about Wall Street and the stock market. One great memorable quote from the movie is when Gordon Gekko tells Fox that "the most valuable commodity I know of is information". Apparently, they are both willing to do anything to get to the top, including trading on illegal inside information. - So, what is the history of insider trading? This is set out below.

Ways to fraud the market….

There are many challenges with the stock market. One main issue is that investors are asked to part with their money, so that companies and brokers can manage the funds for them. This creates a principal – agent issue. The principle – agent problem arises when one party (the agent) agrees to work in favor/ on behalf of another party (principal) in return for some reward. However, if the interests between the agent and the principal are not fully aligned, or not sufficiently regulated, the principal risks that the agent may take advantage of the principal. And in some cases this may turn out to be fraud.

There are numerous ways the shareholders can be defrauded and get parted from their money. Trading on inside information undermines the confidence in the capital markets; what investors would like to put their hard-earned money in the stock markets if the chances of being cheated is a big risk? In addition, over the decades a number of other scams have come up to con the investors, like the following: *Boiler room operations* (a call center selling questionable shares to uninformed investors by telephone), *pump and dump* (which involves artificially inflating the price of an owned stock through false and misleading positive statements, in order to sell the cheaply purchased stock at a higher price); *Ponzi schemes* (where an individual or organization pays returns to its investors from new capital paid to the organization by new investors, rather than from profit earned through legitimate sources), *cooking the books* (the company falsifies its financial statements), *front running* (when a broker trading shares in his personal account based on advanced knowledge of pending orders from clients, allowing him to profit from the knowledge) and many more. Still, for many years trading on inside information was not illegal. Top management could make a gain by selling or buying with inside information, and this was considered as a "perk" for the management. In a landmark case in the US – Goodwin v. Agassiz – Supreme Judicial Court of Massachusetts in 1933 stated that while Mr. Agassiz "had certain knowledge, material to the value of the stock, which the plaintiff did not have," no wrongdoing was committed, the court found. Only in instances where an insider bought or sold shares in a private, face-to-face transaction might -- and the court stressed might -- he have to disclose material information. By buying Cliff Mining stock on the open market, Mr. Agassiz merely had exercised a perk of being an insider (Mr Agassiz had inside information that a mine which had been regarded as exhausted, still contained plenty of copper).

1933: Regulations of securities trading

Before the Wall Street Crash of 1929, there was little regulation of securities in the United States at the federal level. But scams like those described above flourished, and to maintain the confidence of the stock markets, regulations were brought to bear. One milestone was the US Securities Act passed by Congress in 1933, which required among other things that the company disclosed all relevant information to the market, prior to any share issue or listing. The following year, Congress passed the Securities Exchange Act 1934, to regulate the secondary market (general-public) trading of securities, i.e the stock exchanges and their listed companies. At this point insider trading was still not an issue, as the Goodwin v. Agassiz case above shows.

Interestingly enough, these US acts are still in place, but of course have been extensively amended over the years.

1961; the first insider trading case prosecuted in the US

Even though a large degree of regulation was in place for the listed companies after second world war, trading on inside information was not clamped down on before SEC prosecuted its first case in 1961. A company employee had tipped his broker that the firm would be cutting its dividend. Before the company had released this information, the broker sold the stock for his wife and clients. He was fined $3,000 by SEC and suspended for 20 days from the New York Stock Exchange. However, as the story goes, the case was good for business. Clients looking for a broker with an edge lined up to hire him for their trading.

Today trading on inside information is of course heavily fined in the US, and offenders may be locked up for years if they are caught.

Securities regulation in Norway

Norway had no regulations against insider trading before the first real Norwegian Securities Trading Act was adopted in 1985. The background for this law was the deregulation the Norwegian capital markets in early 1980 ("jappetiden"). With growing capital markets opportunities for personal enrichment through economic crime rose dramatically. Finanstilsynet (previously named Kredittilsynet) began in the late 1980s to increase monitoring of securities trading in earnest, following several cases of possible insider trading. The Securities Trading Act has been replaced in later years, and the current Securities Trading Act of 2007 will probably be replaced with a new one next year.

The problem of prosecuting insider trading. And the CEO who did not read his mail

The first cases of insider trading that were prosecuted in Norway in the late 1980s and early 1990s did not succeed, often due to lack of evidence. It is very difficult to prove such cases, it is one person's word against another's. The following case from 1987 illustrates this point:

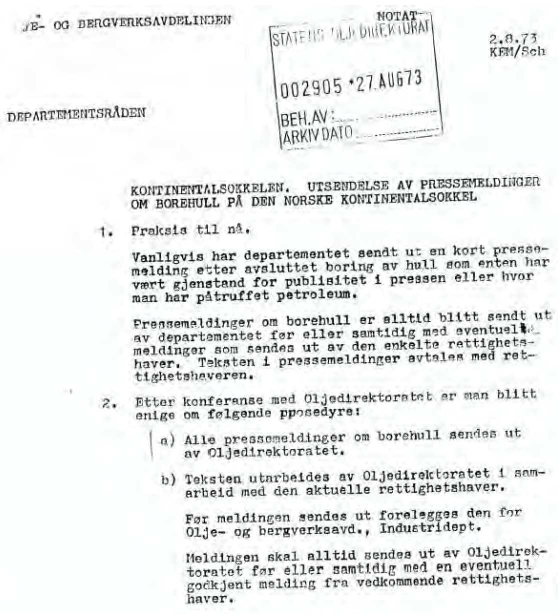
The CEO of Kvaerner Industrier was also a deputy board member of Saga Petroleum AS. He bought 6100 shares in the oil company in April 1987. Just a few days earlier he had received the agenda for an upcoming board meeting of Saga, where it emerged that the company would increase the quota of shares available for foreign investors. Which clearly was advantageous for the share price. A few months after the board meeting he sold the shares with a considerable profit. He later claimed that he had not read those board papers. Kredittilsynet made the case that he had bought shares in Saga on the basis of confidential company information, and investigation pursued. But the case was dismissed by the prosecutors because it could not be proved legally that he had read his mail.

During the 1990s, only three inside cases were brought to court in Norway. The first verdict for insider trading came in 1995 and was for a long time the only one.

Oslo Børs, an exchange for insiders?

Oslo Stock Exchange was at this time criticized for being an insider's exchange, where insider trading threatened to undermine the confidence which is so crucial for the markets. Starting in 2000 Oslo Stock Exchange therefore introduced new monitoring systems of the trading. In addition Norwegian authorities struck down to a much greater degree on inside information. The reputation Oslo Stock Exchange had as a stock exchange for insiders therefore seems to be a thing of the past.

In this story about inside information also the Norwegian oil sector plays a part. Information about the results of exploration drilling is as we all know particularly sensitive information.



JE- OG BERGVERKSAVDELINGEN

NOTAT

STATENS OLJEDIREKTORAT
002905 *27.AU673
BEH.AV:
ARKIV DATO

2.8.73
KFM/Sch

DEPARTEMENTSRÅDEN

KONTINENTALSOKKELEN. UTSENDELSE AV PRESSEMELDINGER OM BOREHULL PÅ DEN NORSKE KONTINENTALSOKKEL

1. Praksis til nå.

Vanligvis har departementet sendt ut en kort pressemelding etter avsluttet boring av hull som enten har vært gjenstand for publisitet i pressen eller hvor man har påtruffet petroleum.

Pressemeldinger om borehull er alltid blitt sendt ut av departementet før eller samtidig med eventuelle meldinger som sendes ut av den enkelte rettighetshaver. Teksten i pressemeldinger avtales med rettighetshaveren.

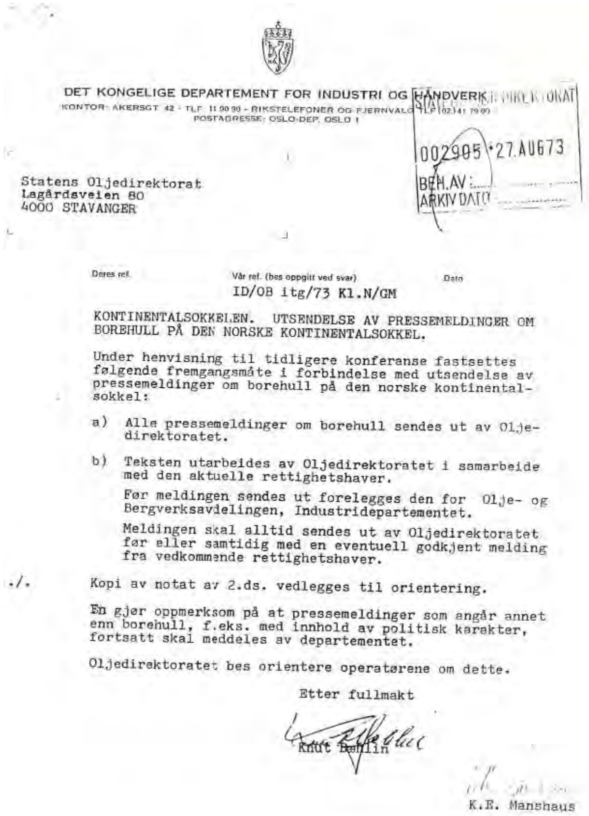
2. Etter konferanse med Oljedirektoratet er man blitt enige om følgende prosedyre:

a) Alle pressemeldinger om borehull sendes ut av Oljedirektoratet.

b) Teksten utarbeides av Oljedirektoratet i samarbeid med den aktuelle rettighetshaver.

Før meldingen sendes ut forelegges den for Olje- og bergverksavd., Industridept.

Meldingen skal alltid sendes ut av Oljedirektoratet før eller samtidig med en eventuell godkjent melding fra vedkommende rettighetshaver.



DET KONGELIGE DEPARTEMENT FOR INDUSTRI OG HÅNDVERK
KONTOR: AKERSGT 42 - TLF. 11 90 90 - RIKSTELEFONER OG FJERNVALG TLF (02) 41 79 90
POSTADRESSE: OSLO-DEP. OSLO 1

STATENS OLJEDIREKTORAT
002905 *27.AU673
BEH.AV:
ARKIV DATO

Statens Oljedirektorat
Lagårdsveien 80
4000 STAVANGER

Deres ref. | Vår ref. (bes oppgitt ved svar) ID/OB itg/73 Kl.N/GM | Dato

KONTINENTALSOKKELEN. UTSENDELSE AV PRESSEMELDINGER OM BOREHULL PÅ DEN NORSKE KONTINENTALSOKKEL.

Under henvisning til tidligere konferanse fastsettes følgende fremgangsmåte i forbindelse med utsendelse av pressemeldinger om borehull på den norske kontinentalsokkel:

a) Alle pressemeldinger om borehull sendes ut av Oljedirektoratet.

b) Teksten utarbeides av Oljedirektoratet i samarbeide med den aktuelle rettighetshaver.

Før meldingen sendes ut forelegges den for Olje- og Bergverksavdelingen, Industridepartementet.

Meldingen skal alltid sendes ut av Oljedirektoratet før eller samtidig med en eventuell godkjent melding fra vedkommende rettighetshaver.

./. Kopi av notat av 2.ds. vedlegges til orientering.

En gjør oppmerksom på at pressemeldinger som angår annet enn borehull, f.eks. med innhold av politisk karakter, fortsatt skal meddeles av departementet.

Oljedirektoratet bes orientere operatørene om dette.

Etter fullmakt

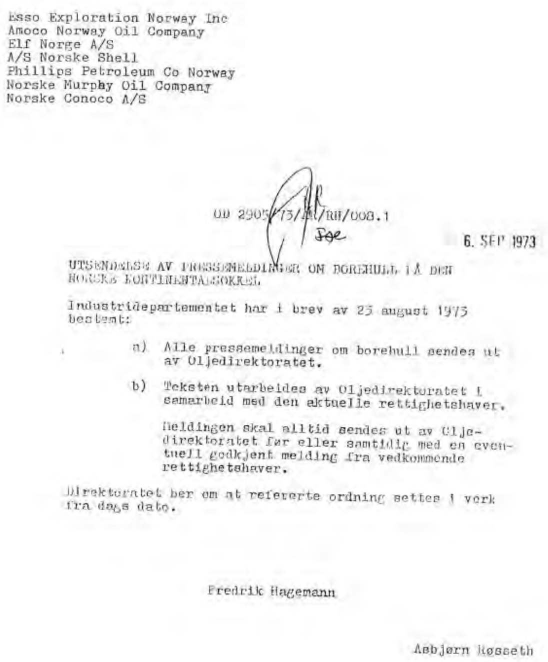
Knut Dahlin

K.E. Manshaus

Information handling of Norwegian exploration drilling – letter of 1973

After the rise of Norway as an oil producing country, for many decades Oljedirektoratet (NPD) was in charge of releasing results of exploration drilling.

The background for the policy was that a foreign oil company in 1973 had published a press release shortly after a significant discovery on the Norwegian sector, while the political leadership was not informed. The political authorities worried that such releases would set the terms for future developments and landing options if this was set out in the press release, and that way effectively overrule the political process. As we all know, regional development is a top priority for all Norwegian politicians. The political authorities wanted therefore to clear in advance all press releases oil companies were


Esso Exploration Norway Inc
Amoco Norway Oil Company
Elf Norge A/S
A/S Norske Shell
Phillips Petroleum Co Norway
Norske Murphy Oil Company
Norske Conoco A/S

OD 2905/73/.../RH/008.1

6. SEP 1973

UTSENDELSE AV PRESSEMELDINGER OM BOREHULL PÅ DEN NORSKE KONTINENTALSOKKEL.

Industridepartementet har i brev av 23 august 1973 bestemt:

a) Alle pressemeldinger om borehull sendes ut av Oljedirektoratet.

b) Teksten utarbeides av Oljedirektoratet i samarbeid med den aktuelle rettighetshaver.

Meldingen skal alltid sendes ut av Oljedirektoratet før eller samtidig med en eventuell godkjent melding fra vedkommende rettighetshaver.

Direktoratet ber om at refererte ordning settes i verk fra dags dato.

Fredrik Hagemann

Asbjørn Røsseth

making for exploration drilling.

2005; smaller oil companies get a license to drill

Fast forward to 2005; when also smaller oil companies were allowed to get exploration licenses on the Norwegian sector. This meant that a number of smaller E &P companies was listed on the Oslo Stock Exchange, in order to raise capital. When these companies got involved in exploration drilling, it became important to deal with this sensitive information in a timely way to investors and the Oslo Stock Exchange. The NPD practice from 1973 meant that up to several days could pass by before any inside information about drilling results was released to the market. This opened opportunities for employees of E&P or oil service companies to trade based on inside information (for instance the drilling crews could see what took place on the rigs). In some cases, the share price of smaller oil companies conspicuously rose in the hours before a stock exchange release was made.

In 2009, Oslo Stock Exchange and NPD agreed to discontinue the practice of NPD controlling the releases from the E&P companies. (The oil company Revus played an important part of this work). Oil companies were then set on an equal footing with the other listed companies with regards to inside information, where the general rule has always been that inside information should be released as soon as possible.

Norsk Olje og Gass (NOROG) also followed up with recommended guidelines on how oil companies should handle inside information in connection with exploration drilling (no 139 - Anbefalte retningslinjer for håndtering av innsideinformasjon).

Impact on operators and oil service companies

An interesting point is also that several of the major oil companies in the NOROG panel that developed the 139 guidelines, initially believed that this guideline might not have any major consequences for them. Either because the result from one exploration well would have insignificant impact on an oil major/operator having a multitude of wells, or that the operator was not listed. While the result of an exploration well may be "make or break" for the much smaller E&P company. In working with the NOROG guidelines, however, the oil majors – listed or not – realized they could be held responsible if any of the company's/operators' employees leaked and/or traded based on inside information. This would also apply to any oil service company involved in exploration drilling.

Summed up

The listed companies' requirements that inside information as a main rule should be released immediately to the market, is crucial for the confidence of the investors. Releasing such information immediately, means that ideally there is no inside information available that Gordon Gekko and his likes could make use of. To the extent inside information is still present (due to certain specified exemptions from the main rule), it is of course illegal to act on this information and can lead to prosecution and fines.

Sources:

The Economist; "The fight against crooked trading gathers pace", Oct 15th 2011 issue
Wall Street Journal; "A 1920s Insider Trade Was Ruled By a Court to Be Merely a Perk" July 3, 2002 issue
Finanstilsynets publikasjon "Erfaringer og utfordringer Kredittilsynet 1986–2006"
Wikipedia

About the author:

Per is a State Authorized Public Accountant and joined PwC in May 2013. Prior to PwC Per worked as listing officer at Oslo Børs for several years, where he was in charge of a number of IPOs as well as the E & P companies' oil reserve reporting. He has also worked as Chief Accountant for Frontline and CFO for Northern Oil, an E&P company listed on Oslo Børs. He works as Director at PwC CMAAS and has over the years been involved in a variety of capital market transactions. He is responsible for several of PwC's internal and external publications as well as seminars covering the capital markets, including facilitating the SPE Oslo Section's full-day E & P seminar at PwC, together with Oslo Børs.

A Method for Determination of Stress and Fatigue in Risers and Wellheads

by Harald Horn, CEO, Ferrx AS; Arild Saasen, Special Advisor, Det norske oljeselskap; Arnljot Skogvang, Staff Project Engineer, Lundin Norway

Arnljot Skogvang
Lundin Norway

Arild Saasen
Det norske oljeselskap

Harald Horn
Ferrx

This year in March, a paper about continuous measurement of pipe fatigue conditions was presented at the IADC/SPE Drilling Conference and Exhibition at Fort Worth, Texas. The paper presents a new and novel non-destructive method for measuring deterioration and cracks in steel structures. Results from stress and fatigue tests with different full scale structures are presented and related to real applications with respect to life-time prediction. Conventional cyclic loading test of riser-pipe elements are documented in the paper for confirmation of the method.

The subject method functions as follows: The material properties magnetic permeability and electrical conductivity, and changes in these, are determined by analyzing the measured voltage response to injected electric pulses. The reponse is transient voltage drop signals, measured under various conditions, and is the basis for calculating parameters representing the stress, fatigue and crack nucleation and crack development in the materials. The degree of material degradation can be used to calculate operational lifetime.

The method has been tested and verified for different types of stress and fatigue loads in different steel alloys. High sensitivity to elastic stress and early detection of permanent changes for high-cycle fatigue testing have been demonstrated with fatigue tests of workover riser pipes. High sensitivity to remanent stress, i.e the steel's ability to "remember" stress (elastic) is a feature that is proportional to the maximum stress occurred since last measurement. On risers, measurement devices can be installed to give the actual condition of the steel for the most exposed locations. Additionally, this information can be used to calibrate the mathematical models for estimating the condition of the whole riser in order to reduce the uncertainty of estimates.

Please refer to IADC/SPE-178856-MS in SPE archive.

How can Integrated Operation contribute to improve the efficiency on the Norwegian Continental Shelf?

by Thorbjørn Kaland, Halliburton, University of Bergen; Ole Seim, Engineer Epsis AS; Jan-Erik Nortvedt, CEO, Epsis AS

Thorbjørn Kaland
Halliburton, University of Bergen

Ole Seim
Engineer Epsis AS

Jan-Erik Nortvedt
CEO Epsis AS

Abstract

This paper will address how Integrated Operations (IO) can assist the oil and gas sector in Norway with implementing more cost effective operations. The paper will initially analyze the implementation of Integrated Operation activities within oil and gas operators and service companies on the Norwegian Continental Shelf (NCS) over the past 15 years. The industry at the NCS has in this period seen a huge growth, and significant value from implementation of IO initiatives has been harvested. Also, a series of "external events" has occurred partly supporting and partly challenging implementation of Integrated Operations. For example, the two largest operators merged in that period, the oil prize raised significantly initially, but dropped back last year. In addition, the efficiency of use of personnel has dropped, the drilling efficiency has gone down significantly, and the overall cost of operating has increased significantly. As a consequence, when the oil priced then dropped in 2014, the industry was quite vulnerable. With this back-drop, this paper discusses how IO can contribute to improve the efficiency on the NCS. We are particularly focused on improvements to the way we work, the relationship between the operator and contractor and on how we are utilizing personnel resources effectively. Key questions are how we can improve on the way of working and decision-making by having much more readily available all relevant information and improving situational awareness and cross-discipline collaboration when making decisions, and how cross-training and new contract structures can reduce the number of people offshore.

SPE-180014-MS

This paper was prepared for presentation at the SPE Bergen One Day Seminar held in Bergen, Norway, 20 April 2016.

Matching of pressure and production history with 4D seismic in offshore carbonate reservoir

by Andrey Kovalenko, Anna Kulikova, Dag Aga , Per-Harald Saure-Thomassen, Statoil

Andrey Kovalenko
Sr Production Engineer

Anna Kulikova
Principal Geologist

Dag Aga
Specialist Reservoir Geology

Per-Harald Saure-Thomassen
Advisor Reservoir Geophysics

1. Gullfaks field location and stratigraphy

The Gullfaks field is located 175 km northwest of Bergen in the Tampen area in the northern part of the North Sea. The field is operated by Statoil ASA, and the license partners in PL050 are OMV and Petoro. The oil discovery was made in 1978 by well 34/10-1. Production started in 1986 and production has been from the Jurassic and late Triassic sandstone reservoirs in the Brent Gp, Cook Fm, Statfjord Gp and Lunde Fm.

The traces of hydrocarbons have also been found in the shallower formations on the Gullfaks main structure. However, these were considered insignificant until recently. Figure 1.1 illustrates the Gullfaks stratigraphy depicting the main hydrocarbon-storing formation as well as the overburden formation with the respective oil shows.

2. Shetland discovery

The new discovery was announced in April 2013, several months after re-perforation of the well 34/10-A-8 in the chalk interval at the top of the Shetland Gp. (Zone 1 on the Figure 2.2). By the time of the announcement, the well has produced over 0,5 Mbbl of oil.

The true vertical thickness of the pay zone was 4,5 m, while the perforation interval measured 4 meters. Since the reservoir is thin, it was interpreted to have a large lateral extent in order to contain enough volume for sustaining the production observed in A-8. The lateral extent of the upper most Shetland chalk interval is supported by the log data from the wells drilled from the Gullfaks field installations (over 200 wells have been drilled since 1979), and by oil shows that were detected in some of the wells. The log response in the wells across the field and the geological interpretation suggest that the thickness of the reservoir varies from 10 m at the central areas of the structure to 2,5-3 m on the flanks before the chalk-rich interval shales out. Figure 2.1 shows the top Shetland structure and thickness of the reservoir.

The deposition for the Shetland chalk is interpreted to occur while the Gullfaks area was a local underwater high, which allowed the cleaner chalk formed from "pelagic rain" to be preserved on the high,whereas off the high siliciclastic material from the continent has diluted pelagic material forming marls. Figure 2.2. shows depositional concept for the Shetland Gp.

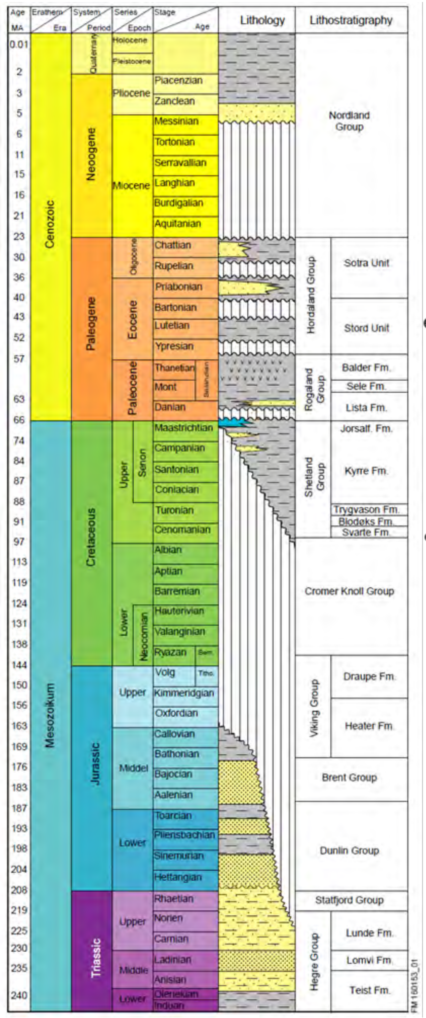


Figure 1.1. Stratigraphy of the Gullfaks Main Field

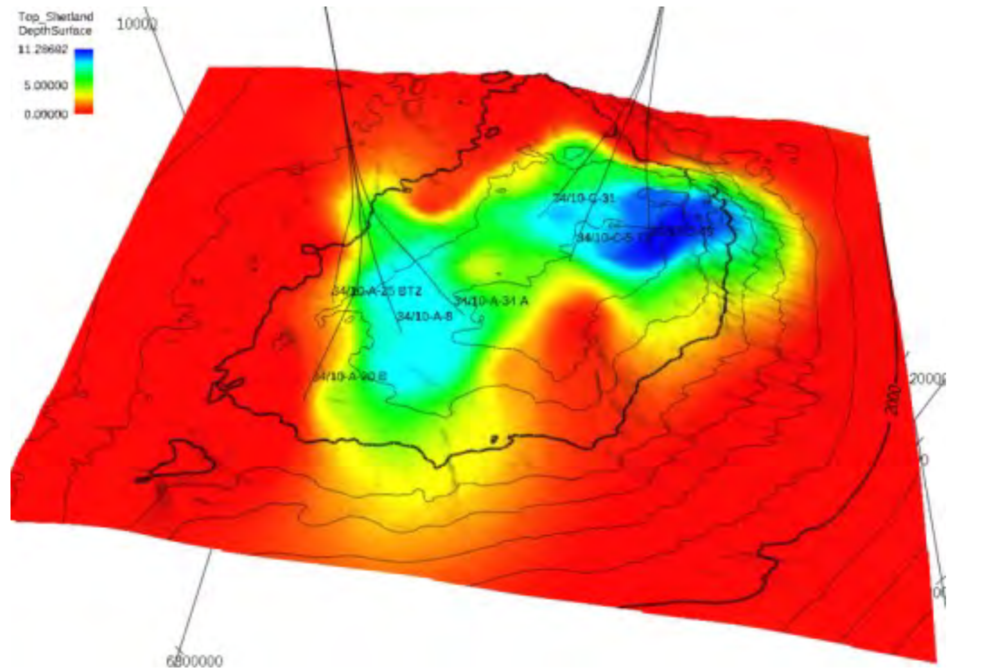


Figure 2.1. Top Shetland structural map overlain with thickness map of the top Shetland chalk interval (zone 1 on the Figure 2.2) at the Gullfaks Main Field

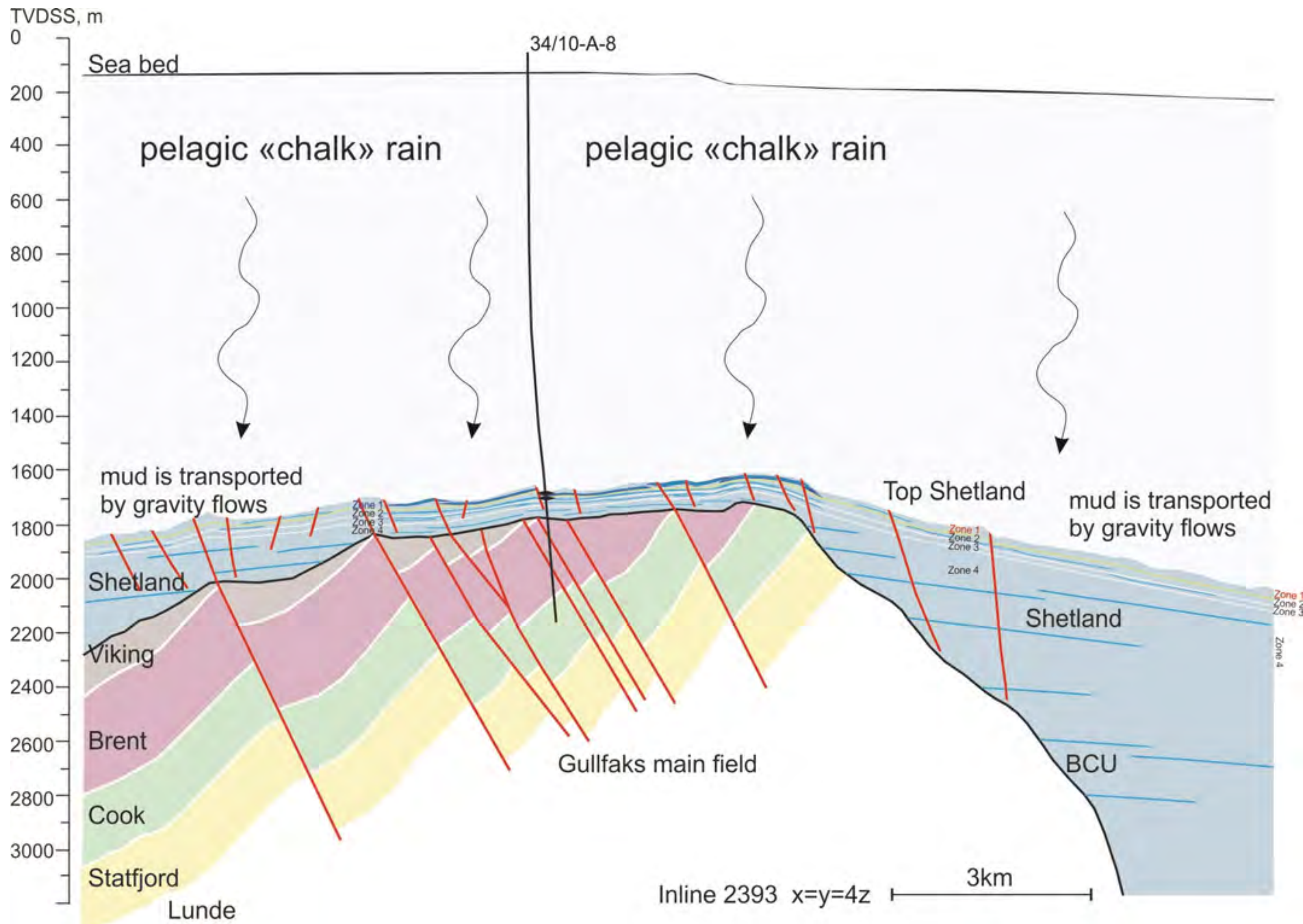


Figure 2.2. Conceptual model for the Shetland Gp at the Gullfaks Main Field.

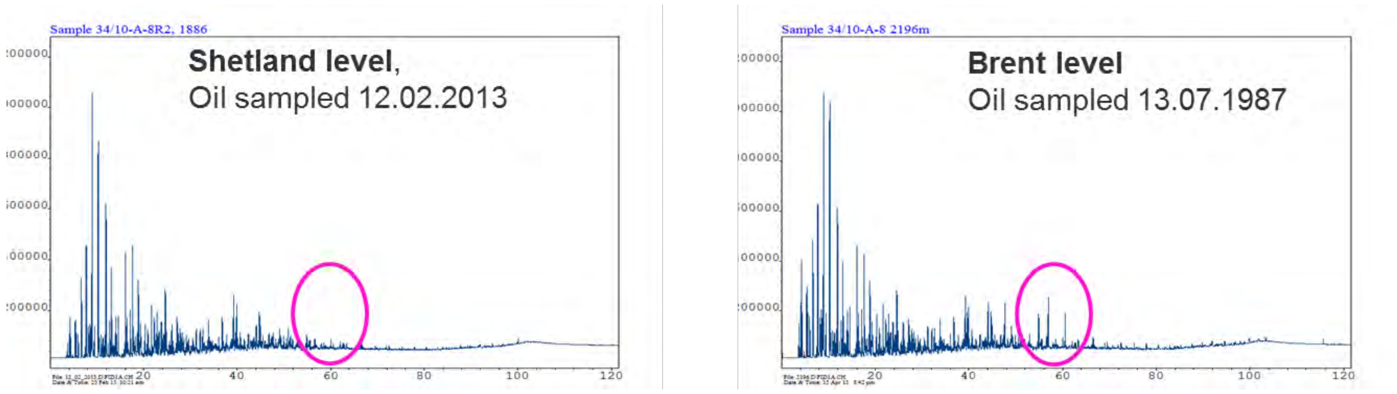


Figure 2.1.1. Oil chromatograms of the A-8 oil samples from Shetland Gp. (left) and Brent Gp. (right)

2.1 PVT and geochemistry

In the beginning of 2013 a downhole sampling was performed in the well in order to secure the most accurate PVT- and compositional data. The sample was then analyzed both for PVT and geochemical properties. While the PVT properties of the Shetland oil were similar to certain types of Brent oils found on the Gullfaks field, the geochemical compositional analysis showed a clear difference in isoprenoid content. The Brent oil used as a baseline was sampled in the very same well, A-8, in 1987. Figure 2.1.1 shows the comparison of the isoprenoid content in the Brent and Shetland oils.

During the assessment of the discovery there has been raised a question whether the oil found in the Shetland chalk has migrated upwards during the production time. However, geochemical findings in the oil from Top Shetland suggest that the oil has been in place over the geological time.

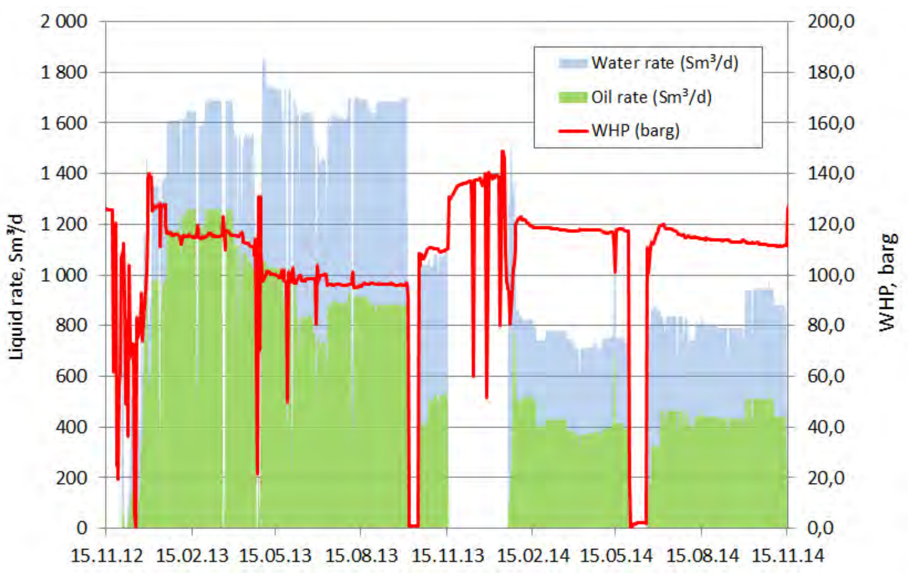


Figure 3.1.1. A-8 production history

3. Production history 2012 – 2014

3.1 A-8 production

Immediately after perforation A-8 was set on stream at a relatively small rate, and later on was open to a liquid rate of 1800 Sm^3/d. After a year of production at this rate, the well was choked back to a rate up to 1000 Sm^3/d, mainly because of water coning and increasing water cut. Figure 3.1.1 illustrates the production history of the well.

In November 2014 the well was closed for pressure observation and further well interventions. During the well's lifetime no new wells were put on stream from Shetland reservoir, except one which discovered a slight pressure communication with A-8, but did not produce any significant amount of fluid while A-8 was on stream. After the shut-in of A-8, more wells were put on production from the Shetland reservoir. There are currently 5 active Shetland producers on the GFC platform

3.2 A-8 PTA model

Having a single well on production in an undisturbed reservoir was a perfect starting point for reservoir modeling process. The measured rates were used along with the pressure reading from a downhole pressure gauge as a reference for model building and history matching.

The purpose of the model built based almost solely on the production data was to characterize the permeability distribution in the reservoir as well as assess the total pore volume by studying the pressure decline. The Saphir part of the Ecrin package from Kappa has been used for these tasks.

The model was built before the representative core sample has been obtained, and therefore the parameters like porosity and compressibility were estimated from the analogs. They were initially assumed constant for the entire field. For the sake of simplicity the thickness of the reservoir were assumed to be uniform across the field. Due to the presence of water from the beginning of production, relative permeability modifiers were introduced in the Ecrin model. They were assumed constant and equal to 0.5. The PVT values for the model were taken from the analyzed samples obtained in April 2013.

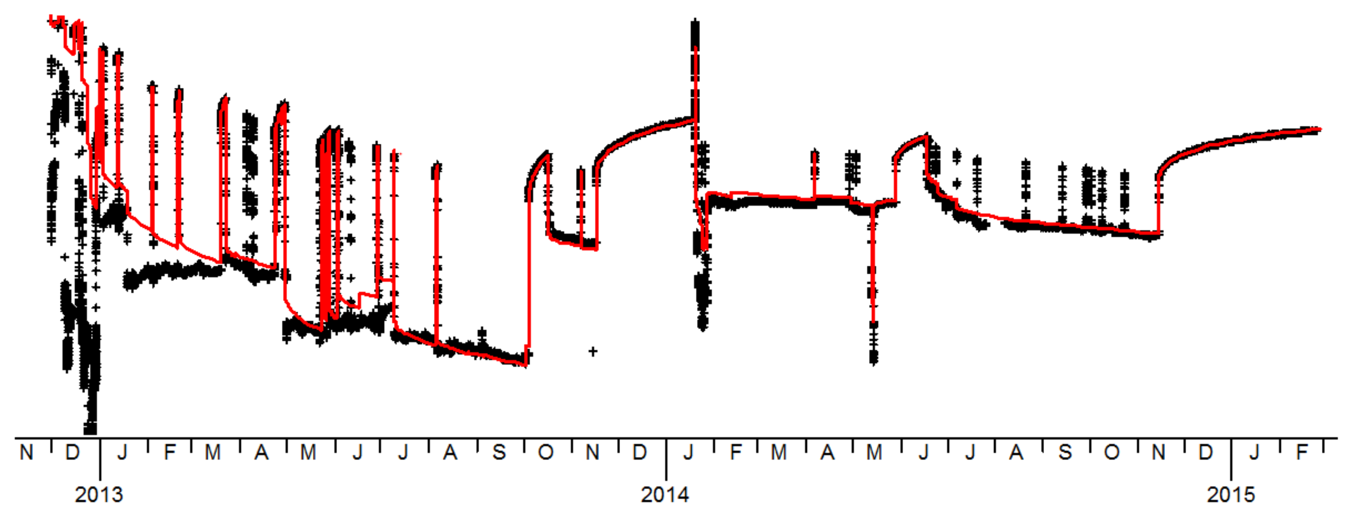


Figure 3.3.1. A-8 pressure history: measured (black) and modelled (red)

3.3 Analysis of the build-ups

The well's behavior during the early production period (until April 2013) was affected by the flow of oil into a flooded zone at the near-wellbore area, which resulted in increasing BHP during production. The pressure history is shown in Figure 3.3.1.

The early build-ups (taken in the period before March 2013) produced inconsistent results. The first build-up showing used as a basis for future interpretation was the one taken in the end of March 2013, the consequent build-ups showed very good agreement to each other. The build-ups used as a basis for the main interpretation were the two performed in the end of 2013 and 2014. These build-ups are shown in the next figure:

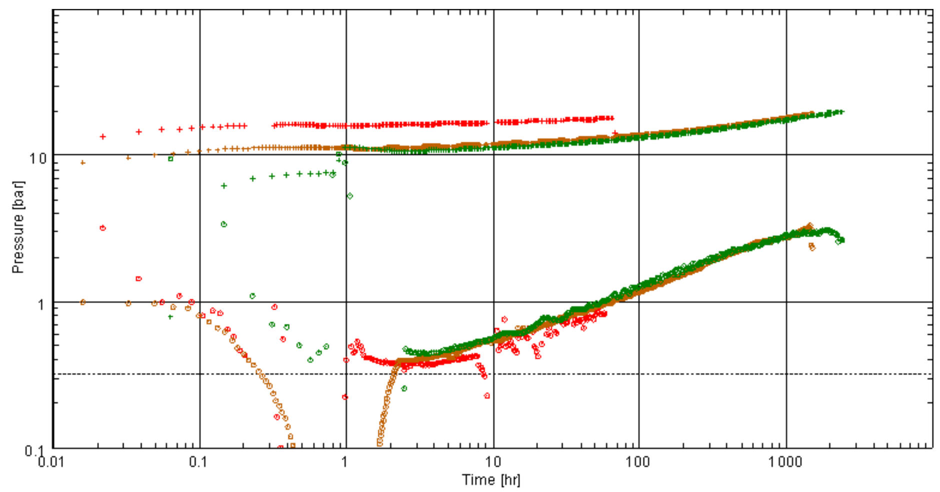


Figure 3.3.2. Log-log plots of the pressure build-ups in A-8: initial (red), 2013 (brown), 2014 (green)

3.4 Final model

In addition to the production and pressure history the faults interpreted from seismic surveys have been taken into consideration. The transmissibility multipliers were assumed to vary in the range 0,1-0,5. The resulting contour was populated with the permeability values from the build-up interpretation in A-8 in the central area, while permeability values on the flanks were obtained via the DFIT tests in the wells perforated in the same reservoir in 2014. The figure below shows the model with the matched permeability values for each segment.

The figure 3.4.2. shows the pressure evolution across the field during the lifetime of A-8.

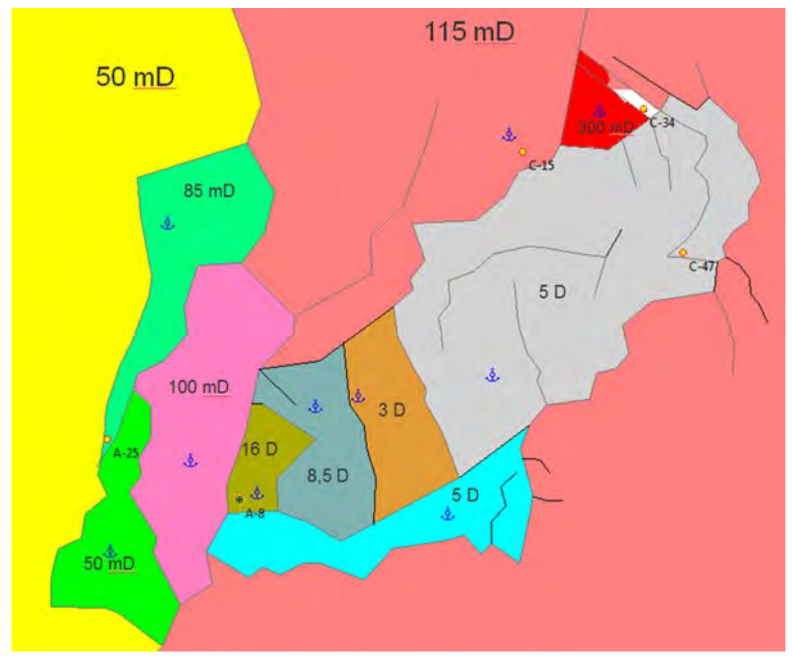


Figure 3.4.1. A-8 reservoir model with matched permeability values

4. Modelling results vs 4D seismic response

In July 2014 an ocean bottom cable (OBC) seismic survey (one of many over the years performed on Gullfaks) was shot. One of the objectives of the seismic interpretation was to assess possible changes in the Top Shetland reservoir from the start of production. The OBC seismic survey from 2008 was used as the baseline for the 4D interpretation, to be able to investigate possible changes due to Shetland production.

The expected response from depletion of Shetland, giving a rise in effective pressure increase the grain contact giving increased P-wave and S-wave velocity. Amplitude and time shift changes have been studied for both compressional waves (PP) and converted waves (PS). A hardening effect is seen on the 4D time shift between 2008 and 2014, and the outline is remarkable similar to the results from the A-8 PTA model. A comparison of the reservoir pressure at the time of acquisition of the 2014 survey and the 4D amplitude changes and the time shift between 2008 and 2014 is given in Figure 4.1.

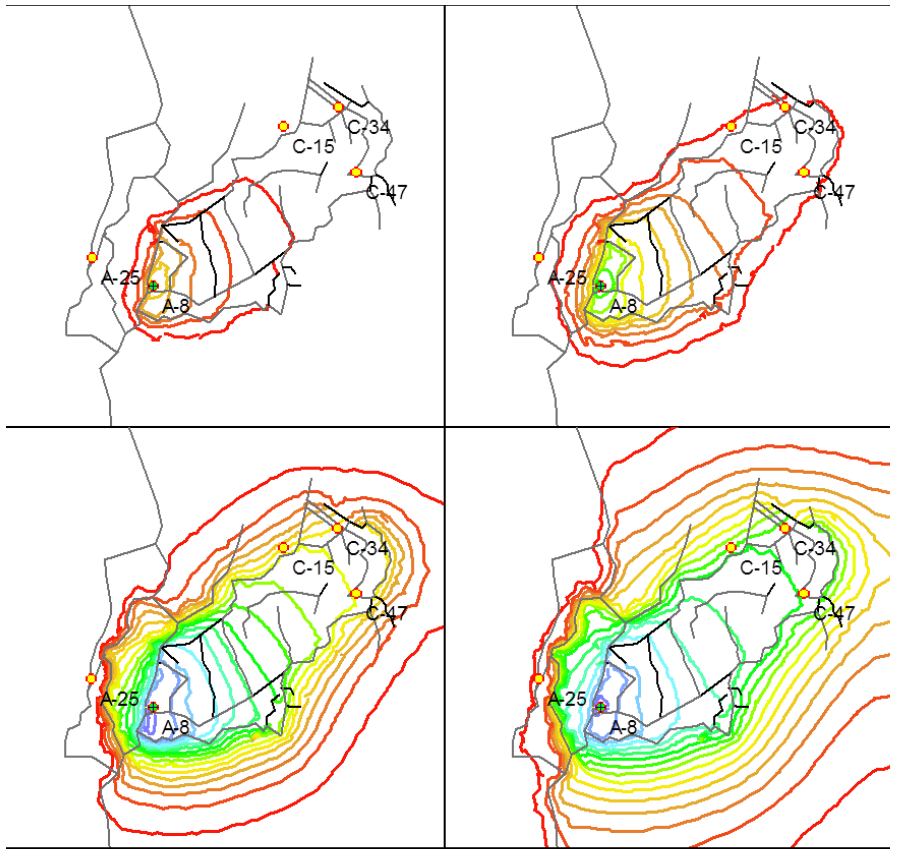


Figure 3.4.2. Reservoir pressure evolution: January 2013 (upper left), March 2013 (upper right), July 2014 (lower left), November 2015 (lower right).

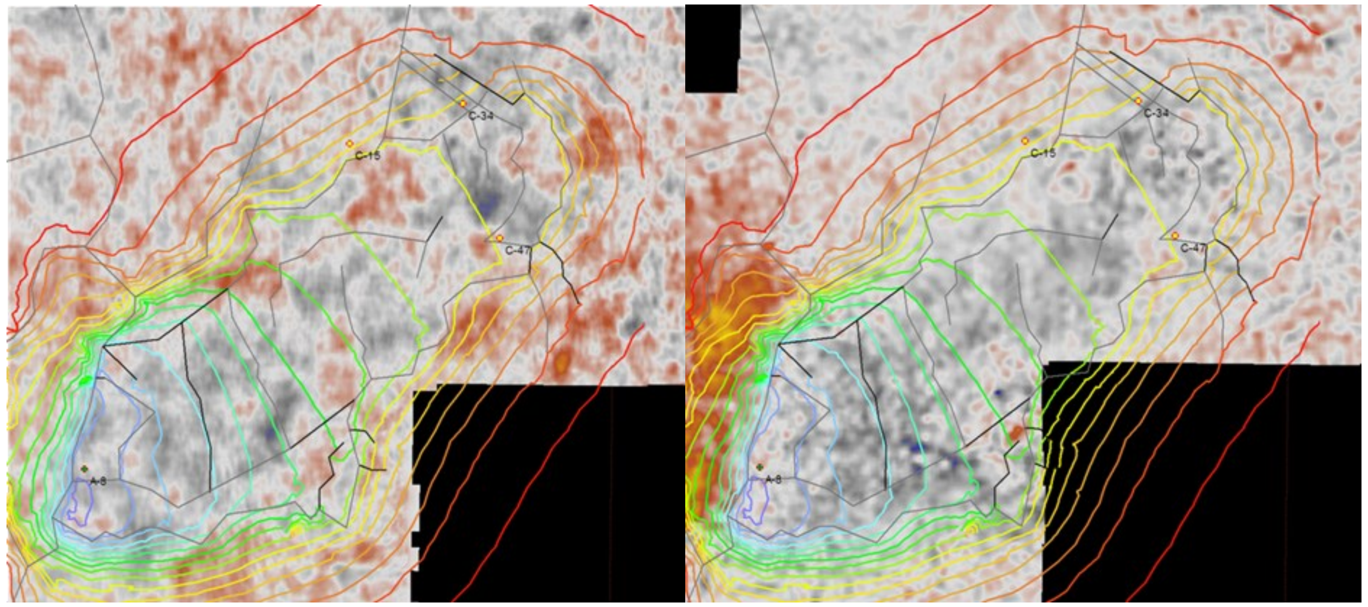


Figure 4.1 4D seismic amplitude difference (left) and time shift (right) at Top Shetland with the pressure map from the reservoir model during the seismic survey in 2014 superimposed. The 4D effect in gray and blue colors is remarkably captured by the A-8 PTA model.

5. Conclusions

The article considers a reservoir model built for a newly discovered carbonate reservoir in the Norwegian sector of the North Sea. The depletion which occurred after 2 years of production is modelled, and the model is history matched. The lateral pressure distribution from the model at the time when the seismic survey was shot is then compared with the 4D seismic interpretation, and the pressure effects interpreted from the seismic response match the pressures predicted by the reservoir model.

The First

Extra-Deep Azimuthal Resistivity for Enhanced Reservoir Navigation in a Complex Reservoir in the Barents Sea

by David Selvåg Larsen, Andreas Hartmann, Pascal Luxey, Sergey Martakov, Jon Skillings - Baker Hughes; Gianbattista Tosi, Luigi Zappalorto - ENI Norge

David Selvag Larsen
RNS Supervisor
Baker Hughes, Norway

Andreas Hartmann
Project Leader for LWD
Baker Celle Technology Center, Germany

Pascal Luxey
Manager
Data and Visualization for LWD Baker Hughes, Pau, France

Sergey Martakov
Senior Scientist
Baker Hughes Technology Center in Houston, USA

Gianbattista Tosi
Well Planning Lead for the Goliat development, Norway

Jonathan (Jon) Skillings
Global Product Manager for Reservoir Navigation and VisiTrak™ Geospatial Navigation/ Analysis Service

Luigi Zappalorto
Senior Operation Geologist, ENI Norway

The abstract below is from the paper that was prepared for presentation at the SPE Annual Technical Conference and Exhibition held in Houston, Texas, 28–30 September 2015. You can search the SPE archive with SPE-174929-MS reference for complete content.

Goliat is an ENI Norge-operated oil field located in the Arctic Barents Sea, 85 km NW of the city Hammerfest. The Goliat reservoirs have a complex structural setting characterized by a large number of faults and a high structural dip towards the flank of the structure. This challenging combination calls for horizontal production wells for effective drainage.

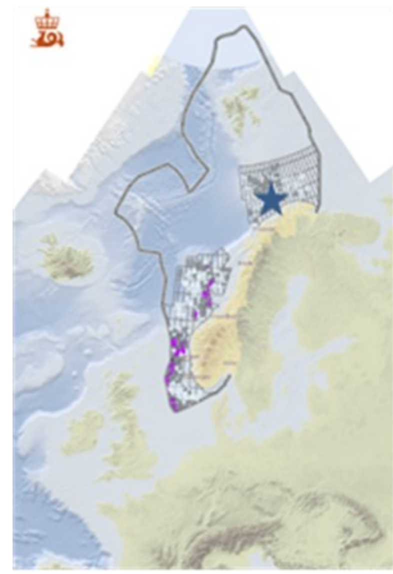
The Goliat field consists of several proven hydrocarbon reservoir units, but to date only Kobbe producers have been drilled. The Kobbe Formation is of Middle Triassic age and is divided into two main Upper Kobbe represents essentially a prograding deltaic system with mouth bars and lobes. In the Lower Kobbe, the system shifts into a more proximal, heterogeneous fluvial setting where sand bodies have limited lateral continuity.

One particular challenge is that the well design requires the 8½-in. reservoir section to be initiated in the overlaying Snadd shale. To minimize shale exposure in the landing section aggressive build-up rates are employed, decreasing the length needed in shale. However, a steep approach may lead to deeper penetration in upper Kobbe, in unwanted intra-shale drilling. Therefore, the key to successful well placement is the early detection of the reservoir top and the accurate mapping of the reservoir sand architecture remote to the wellbore.

One way to successfully navigate a complex reservoir like Goliat is to use extra-deep azimuthal resistivity (EDAR) can detect stratigraphic boundaries up 30 m from the wellbore in optimal resistivity environments (Hartmann et al., 2014). The development of advanced multi-component inversion modelling techniques (Sviridov et al., 2014) enhances the interpretations of resistivity data and can accurately provide real-time information regarding reservoir geometry.

EDAR service provided the capability to detect the top of the reservoir at about 20 m true vertical depth (TVD) and nearly 100 m MD before entering the reservoir, enhancing accurate wellbore landing. Extra-deep measurements also helped the uncertainty in fault detection, where related throw can be estimated based on the displacement of boundaries.

The use of a measurement with increased depth of detection (DOD), combined with advanced multi-component techniques and real-time 3D visualization of data and reservoir model were vital to ensure the successful placement of the well. Real-time mapping of the reservoir geometry was key to optimize reservoir exposure.



The outcrop of the Norwegian Continental Shelf. The star indicates the location of Goliat field. Source: NPD

Lowering Well P&A Costs by Qualifying Alternative Well Abandonment Designs

by David Buchmiller, Senior Engineer DNV GL

David Buchmiller

Senior Engineer

DNV GL

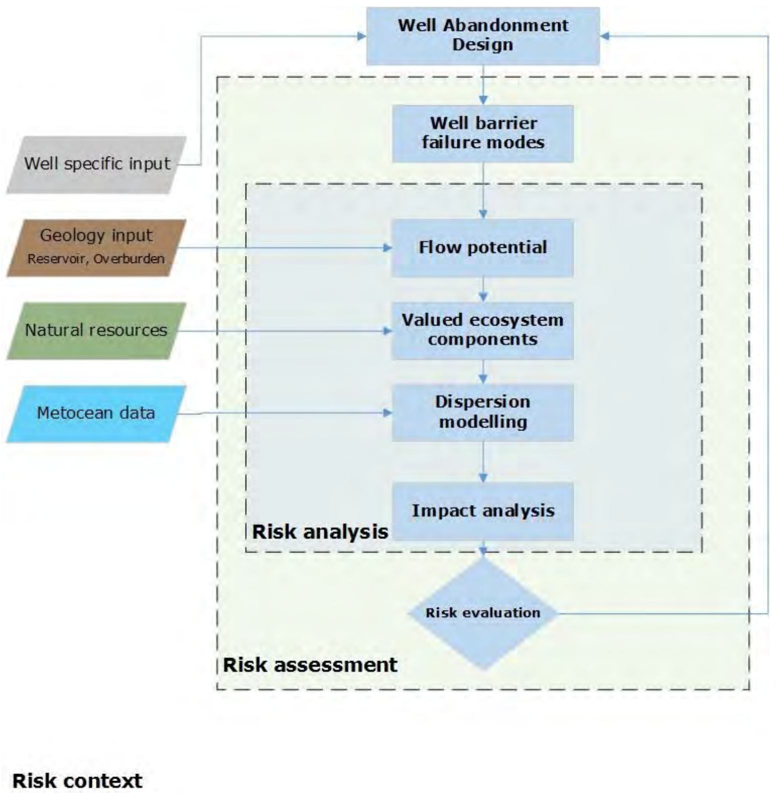
David.Buchmiller@dnvgl.com

The major need for well plug and abandonment has been a highlight at numerous industry conferences over the past few years. Studies performed by Norsk Olje og Gass show that there will be a large rig activity devoted solely to well P&A in the North Sea alone. The Oil & Gas UK agrees, having shown that well P&A is the highest single expenditure in decommissioning budgets.

Major cost savings can be realized by performing fit-for-purpose well abandonment. While global operators and regulators ensure that wells are abandoned successfully and securely, well designs and thus operational savings can be achieved by having well-specific and site-specific well abandonment designs.

Today, well plug and abandonment jobs for both platform wells and subsea wells are planned and performed using prescriptive regulations, such as NORSOK D-010. These requirements prescribe the well abandonment method and details such as the number, type and length of well plugs. Current regulations imply a 'one-size-fits-all' approach. By executing well P&A operations based on the currents prescriptive regulations, the industry is in jeopardy of over spending on well abandonment, especially on subsea wells.

Alternative to today's regulations, DNV GL have released a new, risk-based Recommended Practice (RP) for performing and qualifying well abandonments, entitled DNVGL-RP-E103 "Risk-based abandonment of offshore wells." The RP was released in May 2016 and specifies a systematic process for assessing and controlling subsurface pressures and thus preventing the free flow of pore fluids to the environment. The RP's intention is to provide well operators with an alternative, risk-based method for designing and carrying out well abandonment operations. The ultimate objective of the RP is to protect the environment and ensure safety standards are upheld.



Elements in Well Abandonment Risk Assessment

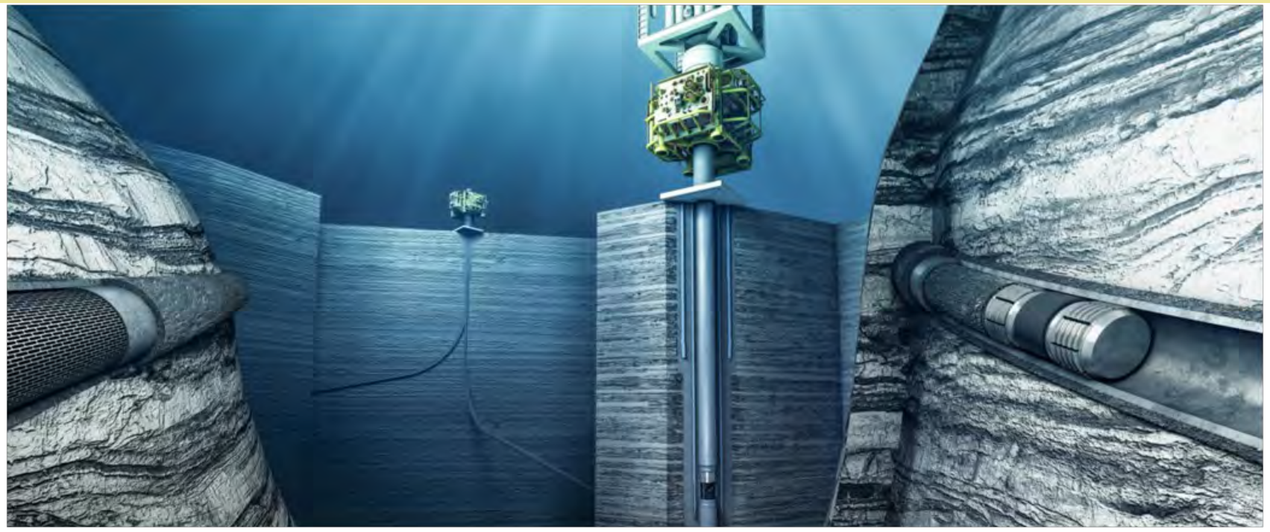
Method

The background for the new DNV GL RP on well abandonment is existing risk management theories and practices, commonly applied in offshore safety risk management and environmental risk management. The RP provides a step-by-step approach, where risks are identified and analyzed individually. Using these techniques, well-specific acceptance criteria for the environment and safety are established, setting the abandonment requirements for each well.

The methodology for performing risk-based assessments of well abandonment designs is composed of five steps. The steps are:

- Establishing the risk context
- Identifying well barrier failure modes
- Performing a risk analysis
- Performing a risk evaluation
- Conducting qualification for well abandonment design.

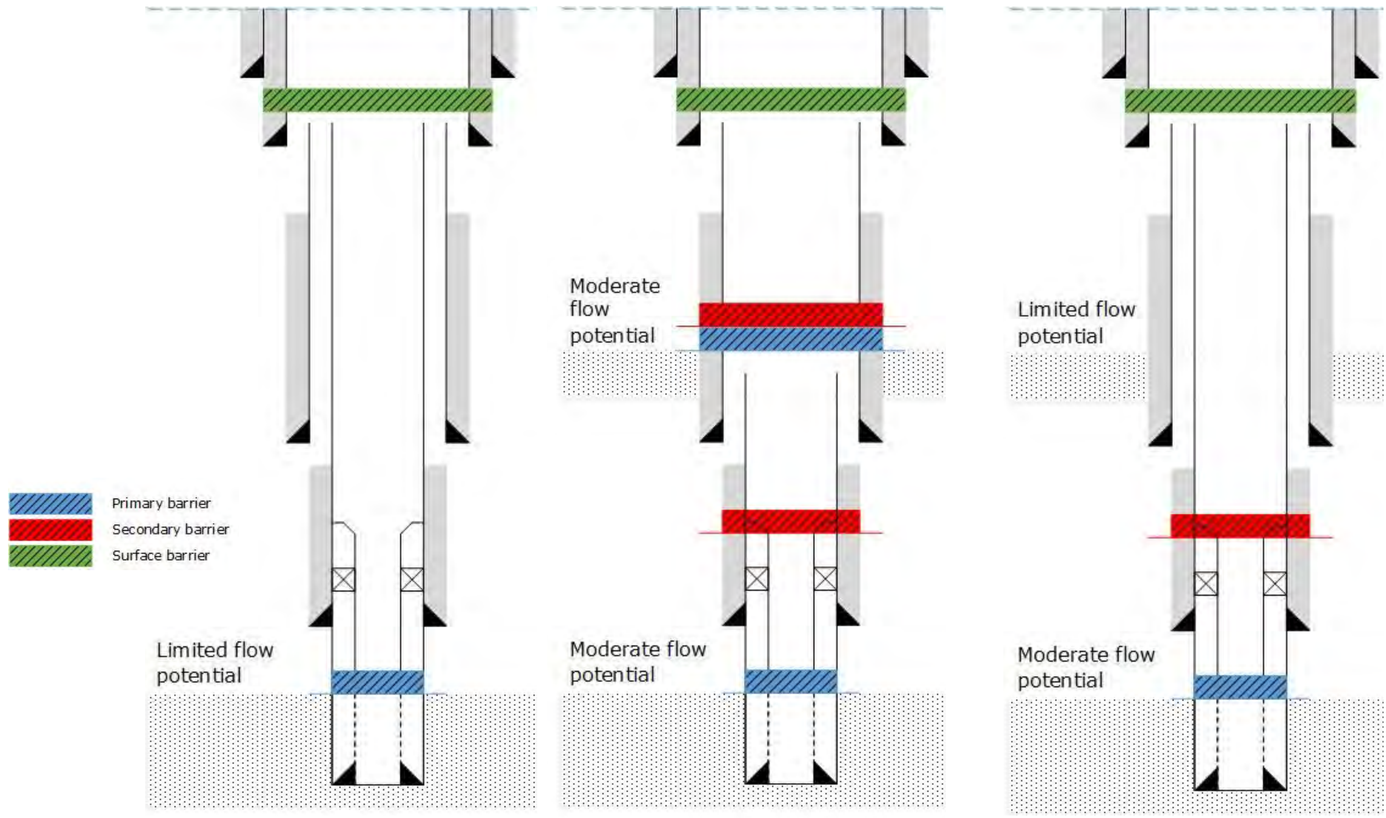
An important part of establishing the risk context is inspecting the flow potential



sources. An assessment of the flow potential of individual formations penetrated by the well is key to the well abandonment design. A flow potential, in this context, is defined as a hydrocarbon-bearing formation containing moveable hydrocarbons large enough to have a potential environmental or safety impact. The well P&A design is an application of the well specific requirements for each hydrocarbon bearing flow potential formation and the permanent barriers required. The specification of the permanent well barrier requirements is a function of the well barrier failure modes and their resulting risk, both in terms of likelihood and potential consequence. The resulting risk may be in the form of operational risk, safety risk or environmental risk. With the risk analysis of the P&A design performed, decision making and comparison of the well abandonment design relative to the risk acceptance criteria can be performed.

Case Studies and Summary

DNV GL has assisted in case studies where significant saving potential has been realized in well abandonment projects. On one specific case study, the well operator was able to save approximately 100 MNOK per well by analyzing their wells up for abandonment from a risk-based perspective. When establishing new well abandonment plans, the overall approach has been to qualify wells to be abandoned for their use and secure long-lasting integrity. Using the risk-based methodology, 'fit-for-purpose' well abandonment designs can be used rather than the current 'one-size-fits-all' approaches.



Example of permanent abandonment for one hydrocarbon-bearing formation with limited flow potential.

Example of permanent abandonment for two hydrocarbon-bearing formations with moderate flow potential in overburden.

Example of permanent abandonment for hydrocarbon-bearing formation with moderate flow potential and with limited flow potential in the overburden.

Using a net environmental benefits approach to evaluate decommissioning options for offshore oil and gas platforms

by Richard J Wenning, Principal, Ecological Services; Nathan Swankie, Environmental Consultant, Principal; Mikkel Benthien Kristensen, Market Manager, Ramboll

Richard J Wenning

Principal, Ecological Services

Nathan Swankie

Principal, Environmental Consultant

Mikkel B. Kristensen

Market Manager

Decommissioning in the North Sea

An increasing number of the world's offshore oil and gas production platforms are reaching the end of their productive life. Approaches for the decommissioning of decades-old infrastructure need to be developed to best suit local environmental conditions, comply with national and international regulations, and satisfy the concerns of commercial fishermen, shipping and other stakeholders with interests in the offshore environment.

At present, the approach to oil and gas platform decommissioning in the North Sea is guided by the 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic. This is known as the OSPAR Convention (so named to reflect the original Oslo and Paris Conventions; "OS" for Oslo and "PAR" for Paris). OSPAR is administered by a Commission representing the 15 governments of the western coasts and catchments of Europe, together with the European Union. The Commission's mandate to protect and conserve the North-East Atlantic Ocean and its resources is guided by an ecosystem approach for integrating management of human activities in the marine environment.

The 1,350 offshore installations operational in the OSPAR maritime area, most are sub-sea steel installations and fixed steel installations, are reaching the end of their useful life. These facilities are managed by OSPAR Contracting Parties with oil and gas industry offshore installations, including Denmark, Germany, Ireland, the Netherlands, Norway, Spain and the United Kingdom.

Since 1998, the leaving wholly or partly in place, of offshore installations that have reached the end of useful life is prohibited within the OSPAR maritime area under OSPAR Decision 98/3, which addresses the Disposal of Disused Offshore Installations. However, a competent authority of the relevant Contracting Party may rely on certain environmental assessments and give permission to leave installations or parts of installations in place. How this assessment process should be undertaken is an important and vexing challenge, at present.

Offshore installations are part of the marine environment

Scientific research has shown that offshore platforms can play an important role in biodiversity and supporting sustainable recreational and commercial fisheries. Offshore structures support marine communities that either naturally occur or have subsequently evolved within the exclusion zones maintained around surface and subsurface infrastructure. Open water and sea floor structures provide habitat for fish that require reef-like structure and similar hard substrate for their lifecycle, and attract many species of migrating invertebrates and fish searching for food, shelter and places to reproduce.

In addition, offshore subsea structures have been shown to provide benefits to marine mammals, threatened and endangered species, and to serve as sanctuaries to protect fish stocks from overfishing. Thus, operating oil and gas fields could be considered, unofficially, as marine protection and conservation areas that limit the ecological pressures imposed by other commercial activities.

Benefits in the North Sea

Research has demonstrated a positive correlation in the US Gulf of Mexico between the presence of infrastructure and commercial fish catch, and encouraged the "rigs - to reefs" program in the US since the mid-1980s. Unlike the US Gulf of Mexico and elsewhere, however, the correlation between the presence of offshore platforms and commercial fish catch is uncertain in the North Sea.

The scientific debate in the North Sea largely centers on changes in fish stock before and after removal of offshore structures. The question debated is whether surface and subsea structures increase the total stock and abundance of commercial species or simply en-

courage their redistribution due to the reef-like effect afforded by the presence of platforms in open water and on the sea floor.

Though oil and gas platforms have been in the North Sea since the 1960s, evidence of the long-term benefits to marine ecology remains uncertain. More research is needed to understand past, current and projected future fish stocks in the presence and absence of offshore platforms.

Is complete removal affordable?

The UK Oil & Gas Authority estimates the cost of decommissioning to the UK as an OSPAR Contracting Party may be as much as £17 billion during the next 10 years. Costs will likely rise to as much as £47 billion by 2050[1]. Energy market research predicts that by 2040 between US$ 70 and 82 billion will likely be spent on decommissioning activities in Denmark, Germany, Norway and the UK, as the North Sea enters a permanent decline in oil and gas production[2]. The UK will claim approximately 60% of this expenditure, as the country with the most offshore infrastructure.

At present the majority of decommissioned platforms are dismantled while in place at sea and transported back to shore for further dismantling and disposal or recycling of the topside, jacket and supporting infrastructure. An offshore platform's support structure has to be completely removed if it weighs less than 10,000 tonnes; but, if the structure is heavier and was built before 1999 (i.e before removal was considered part of rig designs), the responsible owner or operator may apply for OSPAR 98/3 "derogation", thereby allowing some portion of the rig to remain in place.

Falling prices of oil and gas and corresponding cuts in expenditure are driving investigation into alternate, cheaper approaches to decommissioning that also use the assets as economically as possible. Several viable decommissioning options are available for surface and subsea structures. It is, therefore, important to determine which option(s) provide the greatest net benefit to stakeholders while respecting the safety of shipping lanes, commercial fishing and the environment.

Avoiding decision-making paralysis

The escalating costs of decommissioning and absence of sufficient scientific information on the benefits of in-place management of offshore open water and subsea structures cannot, and should not, deter decision-making with respect to decommissioning in the face of the growing number of offshore facilities that have reached their end of useful life. The current default OSPAR requirement under Decision 9/98 mandating complete removal may not necessarily be in the best interest of the oil and gas sector, national economies, the natural environment or future human use.

Net environmental benefit analysis (NEBA) is emerging as perhaps one of the most useful comparative assessment approaches for weighing the environmental risks, benefits and costs between competing decommissioning options. NEBA aides in identifying the trade-offs inherent among the ecological, social and economic factors in environmental decision-making involving decommissioning plans for offshore structures. NEBA has been applied to a variety of environmental decision-making frameworks including contaminated site remediation, environmental impact assessment, oil spill response preparedness and planning and compensatory restoration.

Linking affordability and optimizing environmental benefits

NEBA is a systematic process for quantifying and comparing the benefits and costs between competing alternatives. NEBA and similar comparative cost-benefit analytical tools in that they consider time accumulated service flows (i.e. benefits and costs over time).

However, NEBA takes decision-making analysis one step further by including consideration of non-monetary environmental metrics similar to resource equivalency type methods. NEBA aims to incorporate information on ecological habitat value (e.g. fisheries habitat and associated stock changes), social value (e.g. recreational opportunities to the public such as diving and sport fishing), and economic value (e.g. enhancement to fish stocks affecting commercial fishing and shipping) associated with competing decommissioning options. Other metrics that are also considered in NEBA include chemical hazards, greenhouse gas emissions (GHGs) and implementation risks such as worker health and safety.

Examining the trade-offs between options

Within the decommissioning process, NEBA can be used to evaluate competing options for the disposition of cuttings piles, jackets, and other subsea structures. For example, jacket decommissioning options such as complete removal, partial removal to various depths, conversion to other uses (e.g. rigs to reefs), or a combination of these can be compared on the basis of the net benefit that each option provides from an ecological, economic and social point of view. NEBA can also provide information to demonstrate that a decision meets as low as reasonably practical (ALARP) requirements and considers the wide-range of potential stakeholder concerns.

As offshore platforms in the North Sea reach their end of life, consideration of decommissioning options should be directed at maximising the ecosystem service values to the public. OSPAR 98/3 derogation cases that retain subsea potions of rigs in order to preserve marine habitats and support commercial fisheries should be considered and compared to traditional full removal requirements. Partially decommissioned rigs and substructure could enhance fishery productivity, improve ecological connectivity, and facilitate conservation/restoration of deep-sea benthos such as cold-water corals and other protected and/or valued marine life. Preliminary evidence indicates that decommissioned rigs can also help rebuild declining fish stocks.

Path forward

Using NEBA to support decommission decision-making provides a win-win solution for the environment, the regulatory community, oil and gas sector and other stakeholders that rely on North Sea marine resources. The methodology offers a transparent, scientifically-based, defendable and quantitative approach for comparing different alternatives. The approach can help stakeholders to identify their concerns and, in turn, help operators and OSPAR Contracting Parties to better evaluate their decommissioning options and risks; identify opportunities to create environmental, social and economic value; and, support decision-making based on a defensible science and engineering analysis of the trade-offs between benefits and cost.

Contact Mikkel. B. Kristensen for more information at:

mbk@ramboll.com

[1] oilandgasuk.co.uk/wp-content/uploads/2015/09/Dr.-Angela-Seeney-The-Oil-and-Gas-Authority.pdf

[2] http://www.douglas-westwood.com/report/oil-and-gas/north-sea-decommissioning-market-forecast-2016-2040/

Through Tubing Acoustic Logging for Well Integrity and Flow Allocation

by Rita-Michel Greiss and Chris Rodger, TGT Oilfield Services

Rita-Michel Greiss
Business Development Manager

Chris Rodger
Business Development Manager-Europe

Introduction

In the ever-growing competitive market place in today's oil and gas industry, operators are proactively exploring new and improved means of working in a smarter manner and reducing costs. Within this challenging higher priced environment the health of the well is critical for sustained production and maximizing recovery as we seek to exploit ever more difficult reserves. The ability to be able to log behind casing promptly and accurately identifying well integrity and reservoir issues is fundamental in making smarter business decisions to ensure longevity of field life and optimal sustainable production performance.

This article explores some of the challenges of Well Integrity and Reservoir Flow Allocation facing the industry and how the combination of sonic and temperature logging can provide Oil and Gas professionals with addition information to make informed well decisions.

Well Integrity

Integrity remains at the forefront of well safety throughout the well's lifecycle from drilling through to latter stages of plug-back, abandonment and decommissioning. The basis of well and completion integrity not only encapsulates safety, but also the overall productivity of reservoir and well performance.

Several well integrity studies and surveys conducted in Norway[1] over the years have revealed that the industry needs to revise its philosophy on barrier integrity. Barrier control is an important health, safety, and environment (HSE) factor, critical in avoiding major incidents caused by completion component leaks or during loss of well-control situations.

Monitoring isolation and running diagnostics when signs of failure manifest are essential for maintenance of a healthy well and production strategy. While conventional spinners and temperature logging can assess first barrier leak, there is a technology gap for measuring leaks occurring behind first barrier[2] or for identifying fluid movement between production / injection zones that should be isolated. Fluid can move between such zones via cement channels, bypassing packers or through the formation itself.

Spectral Noise Logging for Well Integrity

The latest generation of high bandwidth, high definition Spectral Noise Logging (SNL-HD) provides unprecedented investigation[3] into the isolating status of completion components, identifying previously undetectable failures in tubing, GLM, SSD, packers and casing leaks. Combining noise logging with temperature logging allows identification of various well component failures, diagnosing critical elements such as the source of sustained annuli pressure (SAP), and identifying complex or multiple annuli communications.

The Spectral Noise Log (SNL) log combined with a temperature log provides the engineer with substantial information on the acoustic pattern of flow within the well.

A typical SNL log gives the well engineer a plot of the noise spectrum and intensity with depth indicating behind casing fluid flows, leaks and annulus communications. (See case study below – figure 1).

Well integrity Case Study – B Annulus Pressure.

In the example below, it was observed by the engineer that there was gas build up in the B Annulus, which resulted in measured surface pressure of 65 psi. TGT Oilfield Services were contacted and requested by the Operator to investigate and identify the source of gas contributing to this casing pressure that was observed at the surface. An integrated well survey including High Precision Temperature (HPT) Logging and Spectral Noise Logging (SNL) was developed to investigate this. The results were as follows:

- Two sources of gas were observed from noise under shut in conditions at depths X726ft to X742ft and X762ft to X780ft (figure 1, shut-in panel)
- Bleed-off survey (figure 1, Bleed –Off SNL Panel), indicated upward movement of gas from the two gas-bearing zones.
- 'Channelling' noise was observed from the source of gas to the shoe, followed by lower –frequency noise as the gas travels between the 13 3/8 in and 9 5/8 in casing to surface.
- Temperature profile gradient change indicates the source of the gas entering the B Annulus

Reservoir Flow Allocation

Reservoir management is a complex process, with many challenges associated with uncertainties in reservoir dynamics, such as flow allocation and accurate material balance.

[1] *SPE 112535 Well – Integrity Issues Offshore Norway, 2008*
[2] *SPE 161983 Leak Detection by Temperature and Noise Logging*
[3] *SPE 161712 Innovative Noise and High Precision Temperature Logging Tool for Diagnosing Complex Well Problems*

TGT Oilfield seeks to mitigate the effects of these uncertainties by aiding our clients in optimizing reservoir performance through technology which focuses on answering how each layer in a well contribute to total production / injection.

When considering behind casing logging of a producer, it is unusual for the borehole (perforation) flow profile to represent that of the formation. The flow geometry behind the casing can be complex, where water bearing layers out-with the perforation interval can contribute significant flow via cement channels or near wellbore fractures.

Likewise, borehole measurements of injectivity profiles can be misleading as injected fluid flows through cement channels or near wellbore fractures out-with the perforation interval

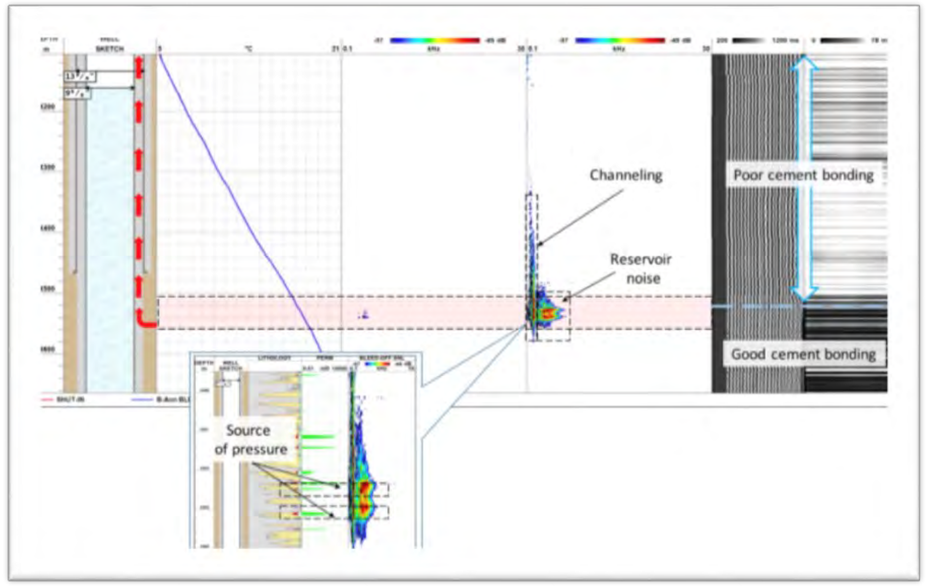


Figure 1: from left to right - depth, well schematic, temperature, SNL panel (Shut-in and Bleed-Off), CBL-VDL

Spectral Noise Logging for Reservoir Flow Allocation

High Definition Spectral Noise Logging's (SNL-HD) unrivalled sensitivity across a wide frequency range enables detection of cement channel flows and identification of all active units[5,6]. Temperature measurements compliment this acoustic profile. Combining open-hole logs, SNL-HD profile and conventional PL tool measurements allows determination of true flow geometry behind casing for complex cases.

SNL-HD, consisting of the latest generation of SNL sonde and a high precision temperature sensor, is run in conjunction with a spinner and multiphase-sensor (capacitance, resistivity, densitometers, Temp and Press) module.

- The spinner is utilised to measure borehole inflow profile and multiphase-sensors to determine relative volumes of fluid phase.
- SNL-HD sonde provides qualitative reservoir flow[7] profile, capable of distinguishing matrix from fracture flow. SNL-HD also provides direct measurement of active flow unit thickness behind pipe. Assessment of fluid movement across completion elements (SSDs, packers, etc) is also acquired.
- Temperature profiles under shut-in and flowing conditions are acquired. These provide qualitative information on fluid movement in near wellbore region. Temperature simulation can be performed, and by building advanced thermal model (and subsequent matching of geothermal) the quantitative flow profile can be solved.[8]

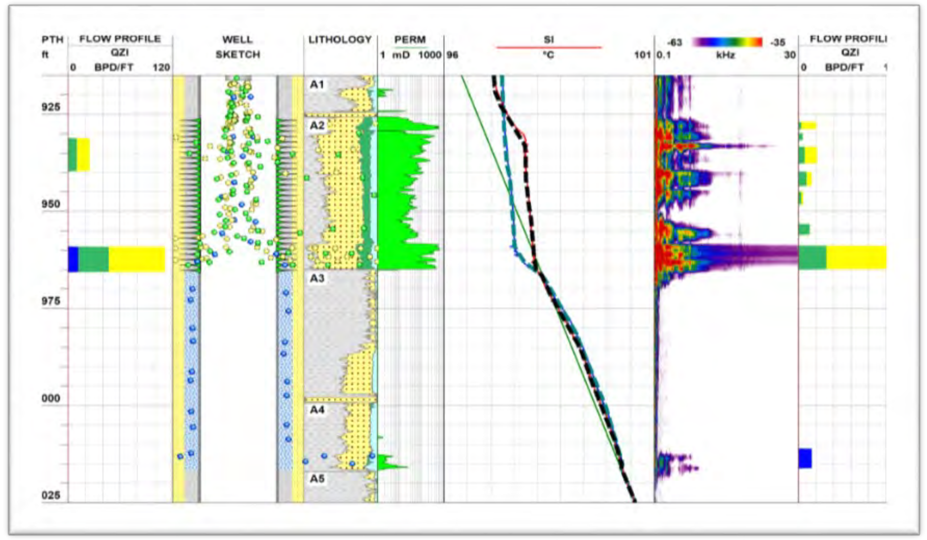


Figure 2: from left to right - spinner flow profile, well schematic, OH log lithology and saturation, OH log permeability, temperature (measured and simulated), SNL panel, temperature flow profile

Reservoir Flow Allocation (RFA) Case Study – Production Profiling

The example in figure 2, demonstrates the limitations of traditional borehole measurements and the need for behind tubing surveying. Based on the borehole (spinner) measurement profile alone, one might conclude that the formation across the lower section of perforation interval is the source of water. A Spectral Noise Log challenges this interpretation as it is clear that a contributing zone lying outwith the perforation interval is providing the source of water even though this zone should be hydraulically isolated with cement. Without this additional information, a suitable work over solution would not have been identified.

[4] *SPE 178112-MS An Integrated Downhole Production Logging Suite for Locating Water Sources in Oil Production Wells*
[5] *SPE 161712 – Innovation Noise and High Precision Temperature Logging Tool for Diagnosing Complex Well Problems*
[6] *SPE 171251 – Identification of Behind-Casing Flowing Reservoir Intervals by the Integrated High-Precision Temperature and Spectral Noise Logging Techniques (2014)*
[7] *SPE 177616-MS – Integrated Formation Micro-Imager (FMI) and Spectral Noise Logging (SNL) for the Study of Fracturing in Carbonate Reservoirs (2015)*
[8] *SPE 16607 – Evaluating Injection Performance with High Precision Temperature Logging and Numerical Temperature Modelling (2013)*

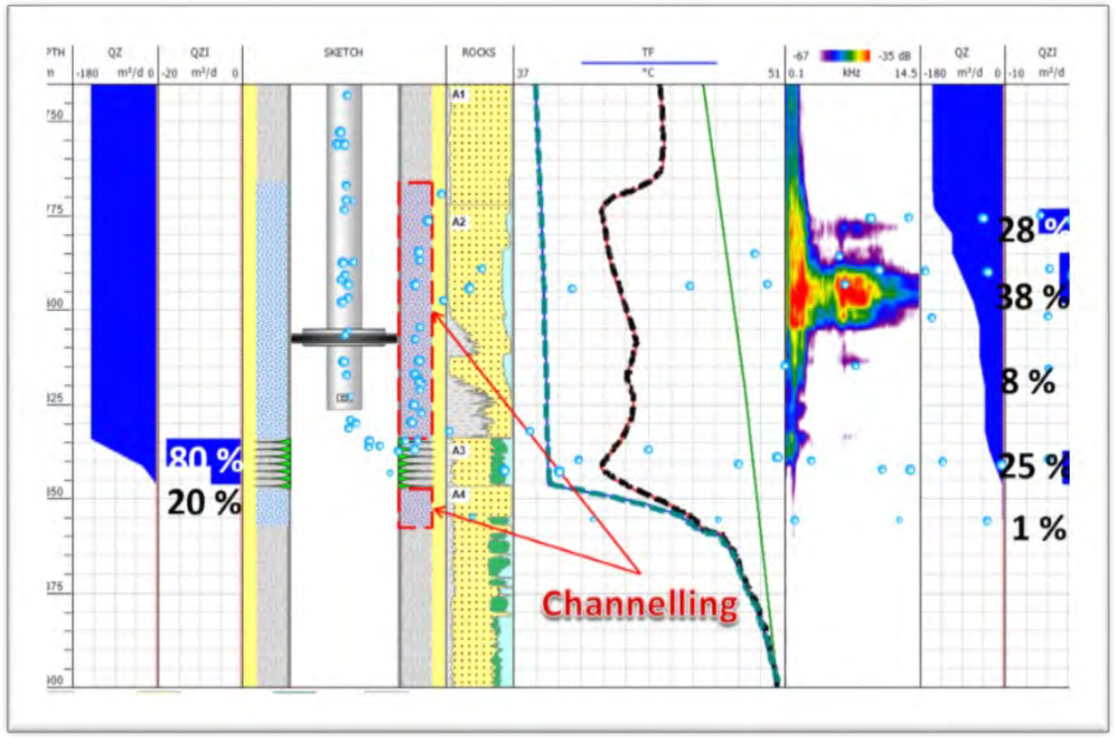


Figure 3: from left to right - spinner flow profile, well schematic, OH log lithology and saturation, temperature (measured and simulated), SNL panel, temperature simulated flow profile

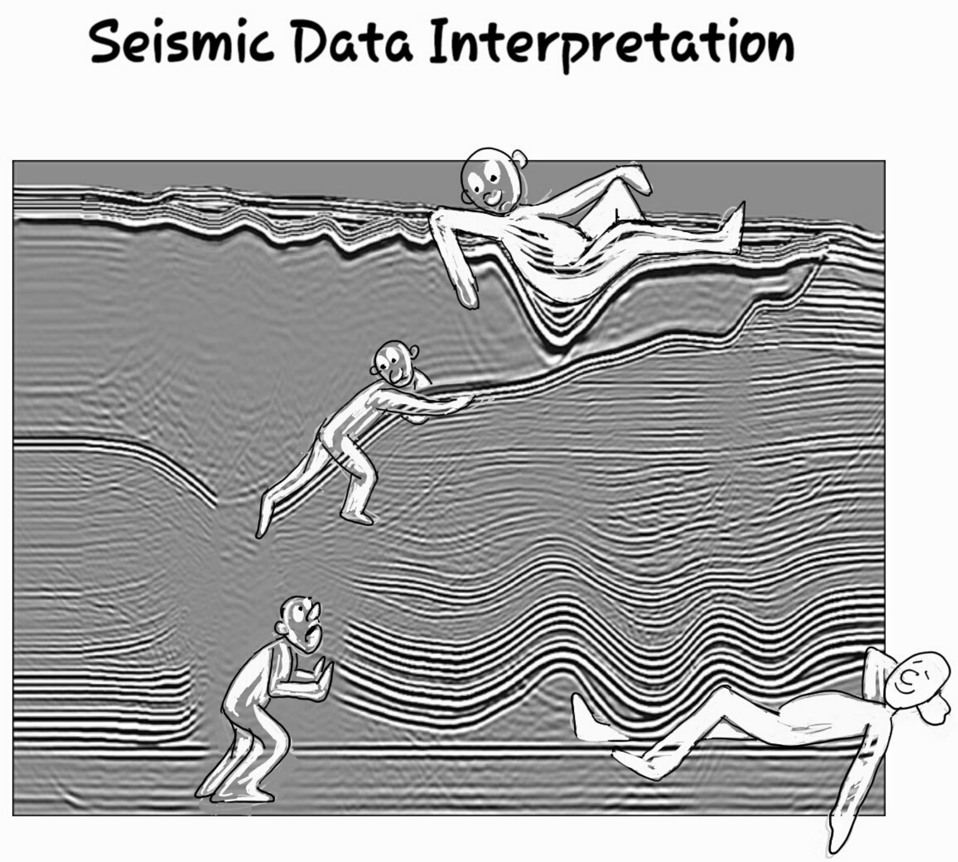
Summary and Conclusion

Evidently the changing economic landscape has and will continue to force the oil and gas industry and related businesses to explore the full advantage of the technological tools available and their importance under various applications to address industry issues.

As can be clearly concluded proper well integrity monitoring is paramount in preventing failures and accidents at wellsite. TGT highly effective leak detection methodology of combining High Precision Temperature and Spectral Noise Logging (HPT-SNL) can monitor processes behind the casing, enabling and ensuring identification of leaks in the tubing, casing and cement.

This same technology of the HPT-SNL, utilised in a different application and mode can aid in reservoir flow description revealing insightful information such as: source of water breakthrough, identification of thief zones, and identification of bypassed oil and additional revenue.

The addition of Spectral Noise Logging aids in the understanding of the true inflow profiles of producer wells and injection profiles of injector wells operating in an asset, information that is critical for production technologists, well integrity engineers, reservoir engineers and petrophysicsts alike.



Digitalising Drilling and Well

by Magnus Tvedt, Founder and CEO of PRO Well Plan

TLDR; 5 min read. It's all about digitalization these days. There is no way around.

Magnus Tvedt
Founder and CEO of
PRO WELL PLAN
magnus.tvedt@prowellplan.com

DIGITALISATION
Digitalisation is a popular word these days in the industry. *Digital* means 1 or 0, true or false - precise and discrete measures. *Digitalisation* means stop doing repetitive work with below par quality, and let computers handle all the heavy lifting. Let's have a look at how to digitalise Drilling and Well.

EXAMPLE
The code in the picture below shows how you choose a mud weight two points above the pore pressure .
What do you mean? No excel sheets, no meetings and back and forths with the geologist? No - in the name of digitalization - we put code behind our decisions. The above code snippet will always give you the correct mud weight, as long as the data you pass in, is in shape. We'll further discuss data quality later, but first, let's lend our eyes to other industries.

MODERN INDUSTRY
To be a modern industry today, you must master your data. Think of jet engines, store management, and social media. Data tells us everything today; who buys what, what is the best racket for your wrist strength, where am I, when will it fail, when are the dishes clean, did the kids lock the door, and so on. Data controls complex operations 24/7; across time zones and continents.

Logistics on roads and warehouses take on enormous datasets, and can pinpoint the best driver, pick the shortest route, and alert the farmer when the milk temperature reaches ten celsius in the truck without cooling. Big data analysis suggests new store layouts when the customer purchasing pattern changes. In Drilling and Well, we will go through the roof in performance when we get a good grip on digitalization. So let's head back to our turf.

DRILLING AND WELL STATUS QUO
Drilling and well operations relies heavily on the operational team detailing the 24 hours leading up to operations. When something changes (it does all the time), this team makes decisions impacting well cost, performance and safety. We rely on that they take in all relevant information, that they have all the necessary training, and that they don't make mistakes. But they are people, like us, so they can never hold all these feats. In a way, we are letting the floor manager in the Mercedes car manufacturing line decide what car he's making that day. Or let the cashier in the grocery store run the business. We promised to talk more about data.

DATA QUALITY AND HOW WE WORK
The single most important issue for our industry as we move forward, is lifting the quality in our data. When algorithms map all the data points together, decisions will mirror

```
let g = 0.0981
let min_mud_weight = 0
let pp_sg = 0
let kick_margin = 0.2 // sg
for (pressure_point in pore_curve){
    pp_sg = pressure_point.value/pressure_point.tvd/g/1e3
    if (pp_sg + kick_margin > min_mud_weight){
        min_mud_weight = pp_sg + kick_margin
    }
}
// min_mud_weight is now 2 points above the pore pressure at any
point
```


the quality of the data. With data we mean pore pressures, procurement strategies, operational procedures, real-time data, and everything that can affect the operations. Our data stretches from overly engineered early phase planning, via the world's most busy (and unpredictable) coastal logistics, to the underperforming real-time reporting of our operations (daily summaries). Today it's acceptable to override a simulation or engineered plan by a gut feeling or hunch, and experiences are often stored in a document. Even if the paper is digital, that's still a manual work process. It seems like we also have to look at how we work.
A way to measure the quality of a workflow is to place a timer in the meeting room (Internet of Spying Things, a booming market). Now, invert that number, and see how much time there is left for quiet, quality thinking and deep problem solving. If you get a sense that the majority of time is spent meeting with colleagues, it means tasks should be digitalised. When meeting rooms become the place to shine in your organisation, there is no incentive for employees to work rigorously, over time, on breaking down complex issues - the weekly meeting behaviour is more important. So we will push more of the repeated work and communication over to software. No doubt we'll get more rewarding digitalized workdays, but what about safety?

```
let narrow_margin = 0.1 //sg
let risk_register = density_plot.map(point=>{
    if ((point.frac - point.pore) < narrow_margin){
        return ['narrow_margin', point.depth]
    }
})
// risk_register will now hold lines like
// ['narrow_margin', 2435] where the
// drilling margin is less than 0.1
```

RISK MANAGEMENT
The code snippet on this page is what a digital risk analysis looks like. Again, when the data changes, the risk matrix is updated. Whoom, like that. Maybe you think: You can't catch it all with algorithms? Well, If you can put a logical explanation to what we are looking for, it will be shining on the risk list, in red, green or yellow. Then you can spend your time on new solutions to remedy the risk picture.

CUT THE COSTS
We'll be drilling wells at half price and double precision - that's our ambition. By connecting more and more dots - equipment, fluids, geology, pressures, drilling practices, sensors, and data analysis. Churning operational experience, modern software and hardware capabilities gives us the best performance tool, with consistent, optimal performance. We can cut expensive contingencies in well design and equipment, and measure real performance. Outputs from the digital well plan are auto generated reports, schematics and detailed operational procedures. Or machine control input if you really want a stretch for modern industry (bring in the robots).

PROSPEROUS PATH
For the longest we have been protected by the complexity and high threshold of entering the business. When smart algorithms opens for other industries to interact with us, we will see a new dawn of advanced operations. There are no other industry where workflows are made for people, both in academic and in physical tasks.
We embrace the tomorrow, as we will get more wells, more projects, and more business in the years to come. Soon we will be fighting for who owns the data, and who has the smartest algorithms.

"We call this the #fightagainstcopypaste, and it's a battle worth every second of our time."

About the author:

Magnus is the founder and CEO of Pro Well Plan AS. He is an enthusiastic entrepreneur, speaker and coder with ten years of experience with international well planning.

Computer optimization of development plans in presence of uncertainty

Key Objective
Maximize the value of the asset to the business

Target the P70 value of the NPV to avoid potential down-side problems

Challenges
Thousands of simulations required to capture various development scenarios with account for uncertainty

Solution
34,000 simulations with different model realizations and development scenarios were run on an HPC cluster

Outcome
Development plan was optimized NPV was improved by 5% compared to the engineering solution

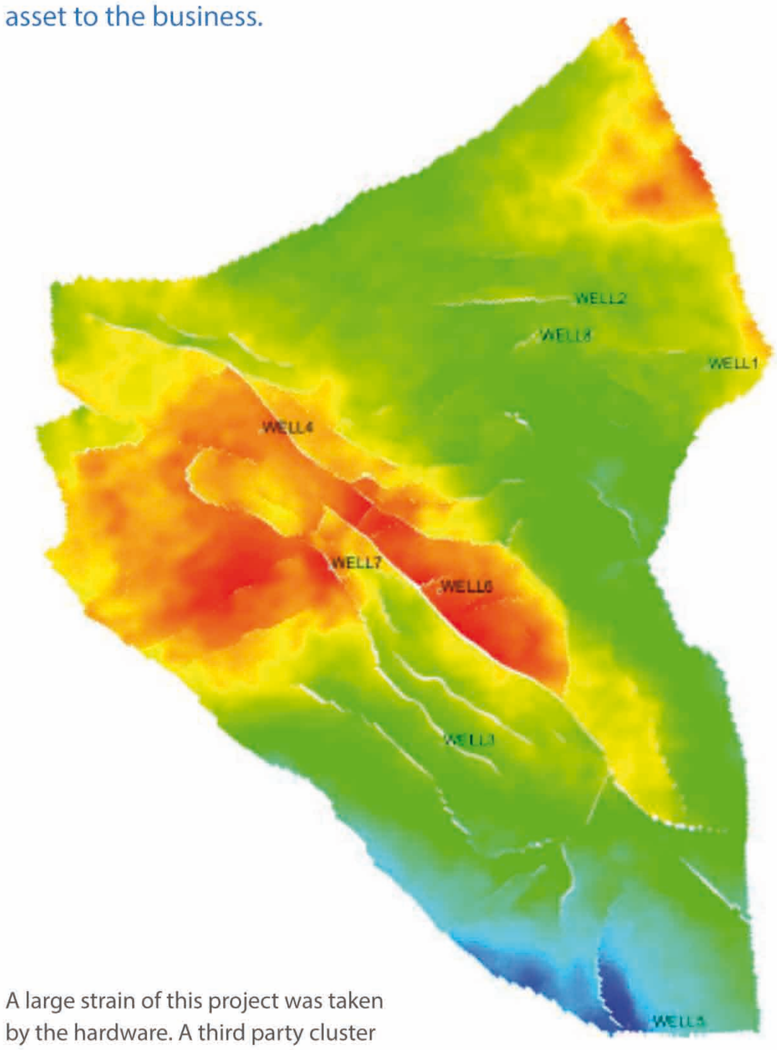
The value added to the project was estimated as 1 billion GBP

"We used about 34,000 simulations, over a three week period on a cluster with 31 nodes each with 16 cores. We estimate that another well known simulator would have needed almost a whole year to complete the same task. "

Dr. Jonathan Carter
Head Technology and Innovation Center for E&P, E.On

Parallel to the original plans of the subsurface modelling team, an independent study was carried out in order to maximize the value of the North Sea gas asset to the business.

The subsurface team built a single geological model as part of their workflow. In this separate experimental study, 31 models were created in order to account for uncertainty based on the reference case.



A large strain of this project was taken by the hardware. A third party cluster cloud solution was used which allowed the reservoir engineer more time to concentrate on additional work.

The development scheme was significantly optimized. The final well placements have some interesting features that challenge the normal design process.

It is estimated that using this approach the cost benefit to the company would be around GBP £1 billion.

The methodology cannot be ignored and challenges the traditional approach to production forecasting and optimization.

A typical UK Northern North Sea oil field: waterflood in a very heterogeneous Brent reservoir

Key Objective
Locating and quantifying the remaining oil pockets, sufficiently large enough to warrant further development

Challenges
Only 26% recovery despite 38 years of water-flood development

Recent wells, based on mapping and material balance could only target 'under-developed edges'

Solution
Use of tNAV to run 100's of sensitivities determining the required heterogeneity to match local water- breakthrough timing and watercut development

Outcome
Fully History Matched model identifies local thief zones with water breakthrough versus layers with remaining oil

Main field locations with sufficient oil can now be targeted

The UK NNS Heather Field has been in production for 38 years with some 90 wells; producers, water injectors and re-completions. The development plan called for producers, supported by (expected) aquifer influx, however, early decline (left) dropped parts of the field below the bubblepoint, leading to liberation of gas: some producers were quickly converted to water injection, but were – as a consequence – not always in optimum positions.

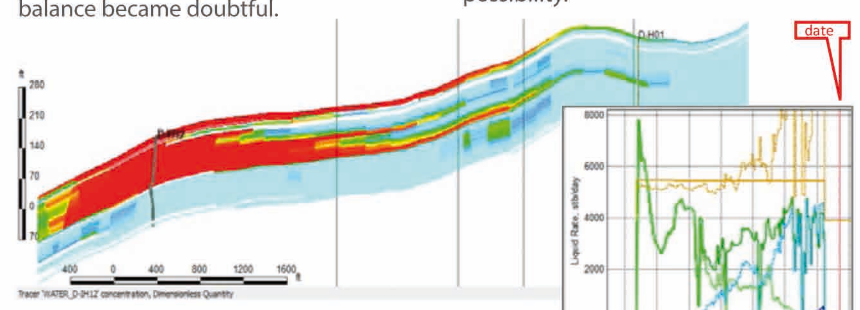
All producers were gas-lifted, making gas production monitoring difficult. PVT was believed to vary considerably throughout the field. So, production of liberated gas was historically not considered a major issue. Material balance became doubtful.

Injection water broke through more quickly than expected, indicating considerable heterogeneity, in common with many other Brent oil fields.

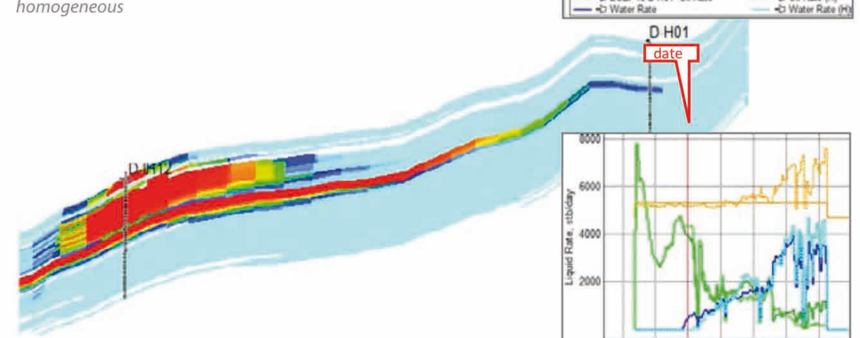
The computer capabilities at the time conspired against a sophisticated reservoir model description and this lead to a *"[widespread] belief [before 2014], that modelling of the Heather Field was a venture of such complexity, that the results would always be of limited use, because the remaining unresolved issues …"*

For EnQuest, the arrival of **tNavigator**® meant, that Heather could be history matched in a multi-layered model with realistic heterogeneity, where water sweeps very small thiefzones, thus defining the remaining oil-in-place. Without prohibitive runtimes.

Rejuvenation of the field is now a real possibility.



Injector-producer pair: Water breakthrough 7 years late due to a permeability description in the static model, that initially was too homogeneous

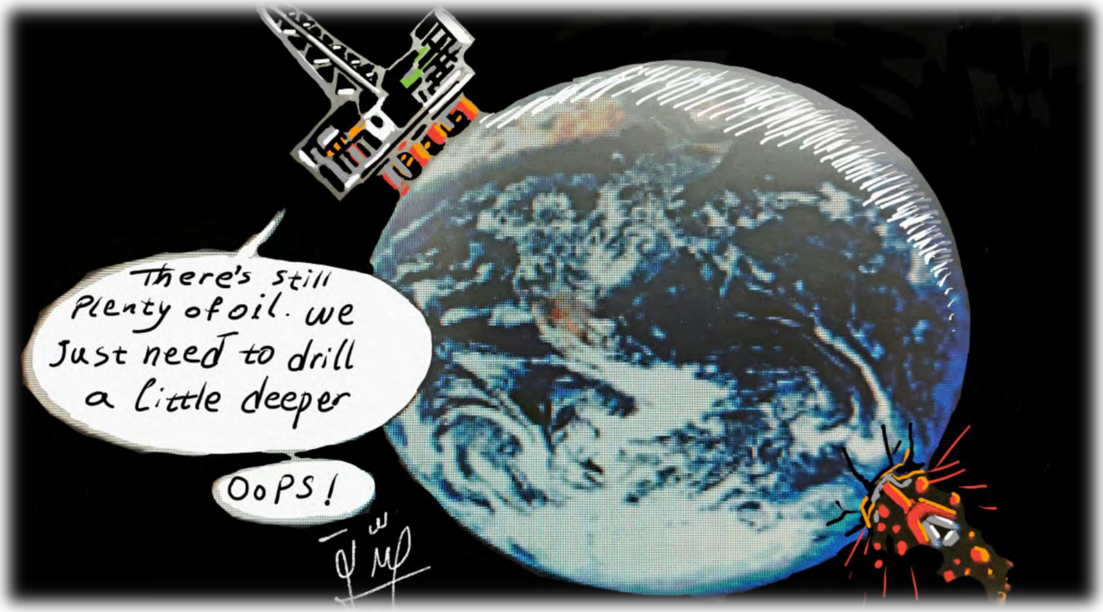


Accurate water breakthrough and water-rate due to HM'd 'thiefzone' heterogeneity description

For more information about tNavigator and the RFD projects please contact scott.harrison@rfdyn.com

Thank you!

TCO
ENGIE
bayerngas norge
Ridge
UTF Underwater Technology Foundation
TULLOW OIL
SINTEF
core energy
Idemitsu Petroleum Norge
SPE International
MAERSK OIL
agr
DEA
nexen
DOMINION GAS
Senergy
Schlumberger
AkerSolutions
EXPRO
Scientific Drilling
interwell
ALTUS Intervention
dana PETROLEUM
Tracerco Providing Insight Onsite
OFFSHORE MEDIA GROUP
CANNSEAL Annular Isolation Technology
BAKER HUGHES
add energy
twma
OREC
GE Oil & Gas
NAMTVEDT SEALMAKER SERVICES
concedo
Norwegian Centres of Expertise NCE Subsea
DNV·GL
welcem



RMN
ABB
Omega
ENHANCED DRILLING
CHURCHILL DRILLING TOOLS
Ace Oil Tools
FMC Technologies
RFD
roxar
Huisman
HALLIBURTON
CABOT
TOTAL
EV
Seal-Tite International Engineered Sealing Solutions
ACONA
KONGSBERG
CLAMPON
VNG Norge
Lundin Norway
pwc
REPSOL
steria
FOUR PHASE
wintershall
E PLUG ADDING NEW WAYS
Welltec
ENVENTURE EXPAND YOUR POSSIBILITIES
IRIS
DNO
HESS
Greene Tweed
Independent Oil Tools as
RaMEX a-s
DETNORSKE
bp
petoro
wellbore
Weatherford
Chevron Human Energy
Statoil
Tomax
gyrodata
ConocoPhillips