London Petrophysical Society

Formation Pressure Testing, Sampling and Interpretation

Tuesday 13th September 2022

Geological Society, Burlington House, London

09:00-17:00 (GMT)

Abstracts

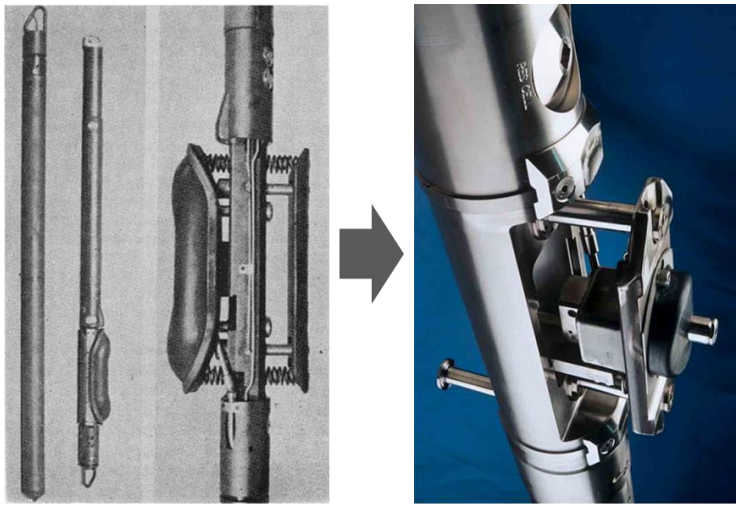
Start Time	End Time	Name	Company	Talk Title
09:15	09:30	Registration		
09:30	09:40	Alina Khmelevskaya	bp	LPS VP Seminars - Welcome and Introduction
09:40	10:15	Don Clarke	ExxonMobil	A Historical Overview of Wireline Formation Testing and Sampling
10:15	10:50	Rudolf Schupbach Thiago Magalhaes	Halliburton	First Fluid Sampling-While-Drilling Operation in Harsh Environment
10:50	11:25	Gavin Sibbald	Baker Hughes	Using AI to Improve and Standardise Job Planning and Large Area Packer Case Study
11:25	11:55	Comfort Break		
11:55	12:30	Emilie Peyret	Schlumberger	Stress Testing: Calibrating Stress Profiles
12:30	13:05	Farrukh Hamza	Halliburton	Determination of Asphaltene On-set Pressure (AOP) at Reservoir Condition Using Wireline Formation Testing
13:05	13:40	Yon Blanco	Schlumberger	Fieldwide Dynamic Pressure Surveillance with FPWD Technology
13:40	14:40	Lunch		
14:40	15:15	Elnur Amirov	Halliburton	Successful Application of Formation Tester 10K psi Sensor Technology in Obtaining Reliable Pressure Measurements with Reduced Rig Time in Caspian Region
15:15	15:50	Marcus Turner	Schlumberger	Optimizing Fluid Scanning & Sampling Success in Unconsolidated Formations While Drilling
15:50	16:25	Trond Rolfsvåg	Hydrophilic	The Prototype Hydrophilic Logging Tool (HLT)
16:25	16:40	Alina Khmelevskaya	bp	LPS VP Seminars - Closing Remarks
16:40	19:00	Networking Reception in the Library		

Register via the LPS website: https://lps.org.uk/events/

A Historical Overview of Wireline Formation Testing and Sampling

Don Clarke, Formation Evaluation Principal
ExxonMobil International Limited

Formation pressure and fluid samples are such a key borehole dataset and are frequently underrated. For all of the value that more conventional LWD and wireline logging measurements bring to our understanding of the subsurface, the formation pressure and fluid data allow us to understand the three-dimensional connections of the subsurface and bring with it dynamic information which is so key to geoscience and reservoir data integration. This technology has seen many advances, from the initial application of recovering a fluid sample to the surface, the introduction of the "pretest" to measure the formation pressure profile of the borehole, to significantly more complex fluid sampling, fluid typing and pressure transient testing to characterize the formation properties. Since the 1950's when this technology was first introduced to the industry, we have been on an ever-increasing technological curve, and it is exciting to see where we end up in the future.



Formation Tester (~1956)

Modular Formation Dynamics Tester (~1990)

Speaker bio

I studied geology and chemistry at the University of Western Australia and did my thesis on Paleocene Nannofossils which kicked off my love affair with carbonate rocks! I joined Schlumberger in 1995 in Australia as a Geologist/Log Analyst and worked the Asia Pacific region until 2002 when I moved to London where I then worked Europe and the Caspian. I joined ExxonMobil in 2003 based in London and continued to work the North Sea and Caspian (primarily Kazakhstan) in Exploration prior to being transferred to Houston in 2008 where I then continued to work Kazakhstan for the Development company including mega carbonate fields like Tengiz and Kashagan. Another transfer to Norway in 2012 had me working field equities and development drilling operations for the Production company, prior to moving back to the UK in 2016. I am now the Formation Evaluation Principal for ExxonMobil globally but remain based here in the UK. I am a strong advocate for the subsurface integration skills of petrophysicists and the value that they can bring to a project.

First Fluid Sampling-While-Drilling Operation in Harsh Environment

Rudolf Schupbach, Geoscientist advisor, Halliburton Sperry Drilling Services

Objectives/Scope: An operator needed to understand the fluid properties of the reservoir while reducing well time and costs in a potentially corrosive environment. Working from a remote semi-submersible rig offshore West Africa, an operator was focused on a horizontal deep water well in which only a Logging While Drilling (LWD) solution was possible for taking representative samples to surface. In order to achieve this operation, special upgrades of the Formation Sampling While Drilling (FSWD) tool were necessary to withstand the potential corrosive fluids. Since this was a "global first" type of operation, the entire Health, Safety and Environmental (HSE) procedures had to be established, approved, and implemented for this specific operation in close collaboration with the operator.

Methods, Procedures, Process: Planning of such a world's first type operation in a remote place offshore West Africa in a deep water environment was key to success. First, a detailed analysis of potential hazards to personal and equipment was conducted and provided adequate solutions to mitigate these hazards. The second step was to document it clearly in new, approved procedures from the operator and service providers management system. After that, the engineering aspect of upgrading the hardware was planned and executed at the Technology facility HQ of the service provider before the FSWD tool was deployed directly to the remote location offshore West Africa, where no adequate workshop facility existed to provide any maintenance or engineering support.

Results, Observations, conclusions: Due to the potentially harsh environment, specific technical upgrades to key components and sensors were required to facilitate a safe and successful operation. The component and sensor upgrades were implemented to meet the required specifications to safely evaluate the reservoir and gather data to facilitate drilling, completion, and production decisions. The FSWD tool was placed in a optimum place with the rotary steerable, drilling engineering designed BHA together with a density, neutron, ultradeep resistivity and high resolution Image sensor. The tool was placed in the "sweet spot" to pump out the water-based mud filtrate and then collected low contamination, single-phase oil samples into pre-charged nitrogen (N2) canisters. Five sample bottles were filled and over-pressurized within 200 minutes of pumping. Normal drilling resumed for the rest of the run, after which the FSWD tool was pulled out of hole to surface. All the necessary safety precautions were taken to remove the sample bottles and mitigate any potential hazardous threat to rig personnel. The five sample bottles were shipped to the customer's PVT lab for analysis of contamination which found to be an accurate representation of the reservoir, according to the customer representative.

Novel/Additive Information: Due to the success of this Formation Sampling While Drilling run, the service is now proven to collect representative formation fluid samples while drilling in a harsh, corrosive environment with a complex drilling BHA in an even more complex well trajectory any place in the world, by collaboration and customized solutions to meet customer needs and maximize their asset value.

Speaker bio: Rudolf Schupbach is the Geoscientist Advisor for Halliburton Sperry Drilling in Europe, Eurasia and Africa region. He holds a bachelor's degree in mechanical engineering 1988 and joined Baker Atlas as a Wireline logging engineer in 1998. Working as a field engineer in the North Sea, Kuwait, Vietnam, Brunei and Malaysia offshore and land based. In 2007 he started his career in Halliburton as a Log Analyst for LWD data in Brunei and was holding different positions in Angola, and Norway. Currently he is located in Switzerland as the regional Geoscientist Advisor for Halliburton Sperry Drilling Services.

Using Artificial Intelligence to improve and standardize pre job planning

Anup Hunnur and Gavin Sibbald, Baker Hughes

With growing complexity of the reservoirs being targeted, the testing and sampling section of the industry has moved to address with increasing variety of packer and pumps. There are now packers with cross section flow area varying widely for specifically targeting conditions expected in the reservoirs and pumps with varying rate and overbalance capability. But these variety of options introduce the new issue of the best packer and pump selection for a given condition/ set of conditions expected in a testing and sampling job.

The complexity is currently being addressed by performing near wellbore reservoir simulation to replicate the expected conditions during the testing and sampling operation. Given the wide variety of packers and pumps, this can at times result in extremely large number of simulations followed by the analysis of picking the options. Any changes in the condition would result in everything having to be re-simulated and reanalyzed.

To simplify the overall process, a set of Artificial Neural Network (ANN) models were created for each of the packers currently in the portfolio. Each packer model was created with the help of 2000+ near wellbore fluid sampling simulations to cover a range of parameters such as porosity, permeability, kv/kh ratio, depth of invasion, viscosity and pressure drops. The training set for each packer model comprised of about 1600+ simulations (80% of the overall simulations) while the remaining simulations were used as test versions to pick the best model. Once the best model was determined, a further set of 400+ simulations were added to the test set to test the boundary limits of the parameters on the model.

The best model for each packer was picked such that the error on the test simulations were not only the least but also showed no specific parameter bias. The models result matched the test simulation cases to less than 2% error on all packer models developed.

The ANN model can simulate a variety of packers over a variety of reservoir conditions in a very short time. It can output over 9000+ cases can be done in 30 min with an engineering grade laptop. Simplified plotting allows user to quickly plot comparison plot along with a streamlined table tabulating results for all the cases. The tabular result is then used to pick the best packer and pump combination for a set of reservoir conditions.

Case Study

Technology Update

Multi zone, low mobility formations can be a challenging environment to sample in. Typically, in the past resulting in the use of inflatable packers to achieve the objectives. Inflatable packers obviously increase the chance of getting stuck or swabbing maybe become an issue due their deformation. Therefore, the need for a very large area probe/packer for sampling comes in handy. Easily deployable, quick and gives enough flow area to target specific mobilities to pressure test and sample from, a large area packer has been designed to target these conditions and has been widely used in challenging formations that have low mobility in a variety of wellbore sizes. The case study will cover the deployment, operational time and effectiveness against inflatable packers and discuss the best methodology and practicality of the large area packer.

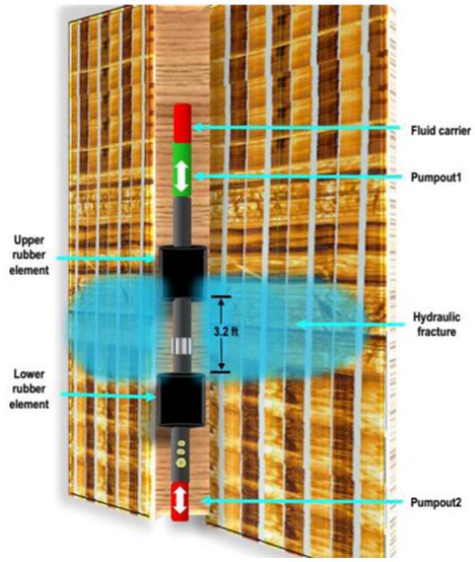
GAVIN JG SIBBALD graduated with a MSci (Hons) in Geoscience from the University of London and PDip in Reservoir Engineering from Heriot – Watt University. With 20yrs of industry experience, having worked offshore as wireline field engineer in the Norway and UK sector, with his current role as North Sea/Europe Reservoir Engineering Discipline Lead, overseeing wireline and LWD formation testing and sampling operations.

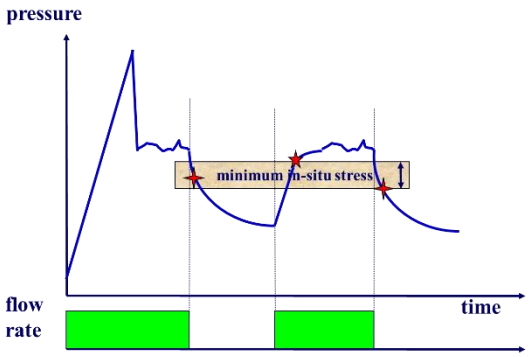
Stress Testing: Calibrating Stress Profiles

Since the inception of formation testing in the 1990s, it has been extensively used for various oilfield applications for conventional and unconventional reservoirs, sampling and transient testing; stress testing is one of the many applications. Stress testing or micro hydraulic fracturing measures minimum horizontal stress insitu at a specific depth. A direct measurement of the minimum horizontal stress of the cap rock relates directly to the maximum safe injection pressure that can be used in the reservoir layers below said cap rock. This can directly impact production, and/or the amount of fluid that can be stored in an underground storage. This direct measurement is a calibration point for the geomechanical models, lowering the uncertainty that exists, and de-risking the reservoirs.

Characterizing the current state of stresses with a formation tester over a caprock and a reservoir or even over an entire lithological column is becoming more in demand with the increase in storage projects and the energy transition underway. The complexity of the formations to be tested, from deeper, harder rocks, to tighter more impermeable formations such as caprocks means that new workflows need to be to be built to maximize data accuracy as well as efficiency.

Current day stress testing capabilities and improvements in the hardware will be discussed as well as different methods available to evaluate tight formations in order to estimate closure stress. These will be discussed through case studies.





Emilie Peyret: Reservoir Domain Champion at Schlumberger, with a diverse experience in wireline formation testing and sampling and stress testing. She has worked in Kuwait, Mexico, Central and West Africa, and Europe.

Determination of Asphaltene On-set Pressure (AOP) at Reservoir Condition Using Wireline Formation Testing

Farrukh Hamza, Halliburton

Flow assurance is a vital challenge that affects the viability of an asset in all oil producing environments. A proper understanding of asphaltene precipitation leading to deposition lends itself to reliable completions planning and timely remediation efforts. This ultimately dictates the production life of the reservoir.

The Wireline Formation Tester (WFT) has traditionally aided the understanding of asphaltene composition in reservoir fluids through Downhole Fluid Analysis (DFA) and the collection of pressurized fluid samples. However, an accurate and representative measurement of Asphaltene Onset Pressure (AOP) has eluded the industry. Although lab measurements of AOP are often sound, there are inherent challenges that affect the quality of the results. These challenges primarily include the need to restore samples to reservoir conditions, maintaining samples at equilibrium composition, and the destruction of fluid samples through inadvertent asphaltene precipitation during transporting and handling. Hence, there is a need for WFT operations to deliver a source of reliable analysis, particularly in high-pressure/high-temperature (HP/HT) reservoirs, to avoid costly miscalculations.

A premiere industry method to determine AOP under in-situ producible conditions is presented. Demonstrated in a Gulf of Mexico (GOM) reservoir, this novel technique mimics the gravimetric and light scattering methods, where a fluid sample is isothermally depressurized from initial reservoir pressure; simultaneously, DFA monitors asphaltene precipitation from solution and a high-precision pressure gauge records the onset of asphaltene precipitation. This measurement is provided continuously and in real time. An added advantage is that experiments are performed individually after obtaining a pressurized sample in distinct oil zones. Therefore, the execution of this downhole AOP experiment is independent of an already captured fluid sample and does not impact the quality of any later laboratory-based analysis. Once the measurements are obtained, these can be utilized in flow assurance modeling methods to describe asphaltene precipitation kinetics, and continuity of complex reservoirs. For the first time in literature, this study applies these modeling methods in combination with the AOP data acquired from a downhole WFT (*Figure 1*).

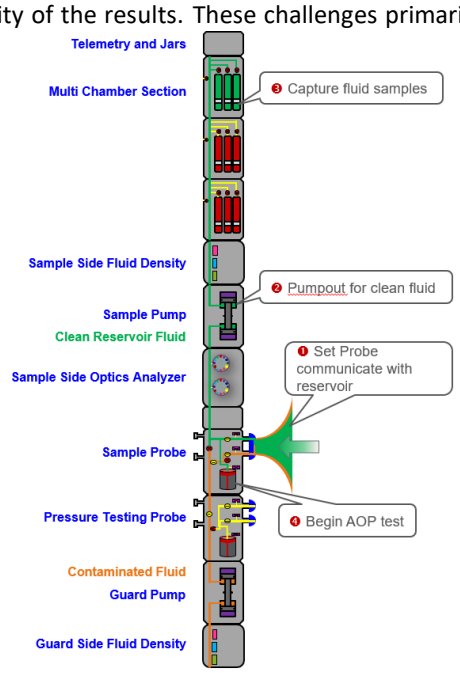


Figure 1: WFT configured to perform downhole AOP measurements. The green cone and flowline signify clean oil. The orange line signifies contaminated fluid when configured for sampling by means of focused pumpout. The numbered operations denote the sequence.

This approach has the potential to create a step change in reservoir analysis by providing AOP at the sand-face. The results of which have tremendous economic implications on production planning.

Farrukh Hamza is a Reservoir Engineering Team Lead at Halliburton's Center of Excellence in Houston for formation evaluation. Hamza has worked extensively on both onshore and offshore reservoirs, around the globe. Hamza has authored 20+ industry publications and holds 10+ patent applications. Hamza holds a bachelor's degree in mechanical engineering from NED University of Engineering and Technology, a master's degree in petroleum engineering from the University of Texas at Austin, and a master's degree in analytics from Georgia Institute of Technology. He has served as a committee member and session chair at various industry conferences and serves on the SPE committee for the development of the petroleum-engineering-certification exam.

FIELDWIDE DYNAMIC PRESSURE SURVEILLANCE WITH FPWD TECHNOLOGY

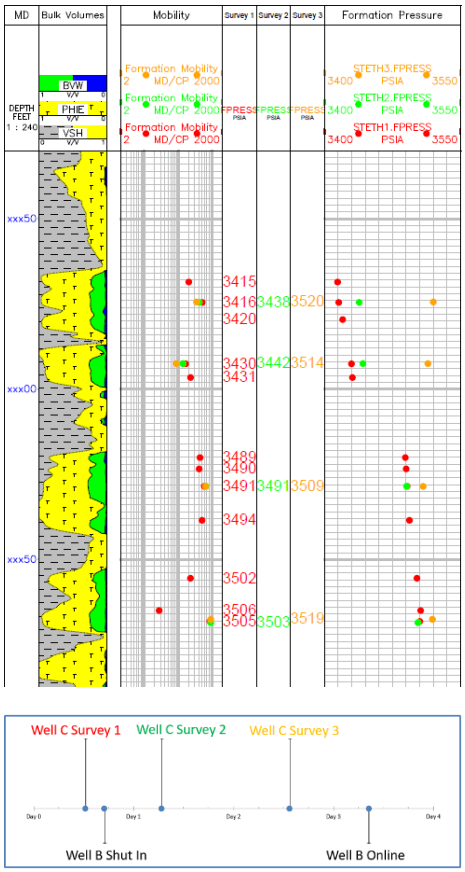
Reservoir management utilizes time-lapse pressure data that is captured over years in order to monitor reservoir development. Several methods can be used to establish field-wide hydraulic lateral and/or vertical connectivity: well testing, monitoring of permanent downhole gauges, wireline and LWD formation testers.

While a typical formation pressure survey provides information about reservoir depletion or charge (production or injection), in a field with several wells it is not clearly understood where the pressure disturbances are coming from, which can hamper further field development decision making in terms of infill well selection and drilling.

A novel method is introduced where a Formation Pressure While Drilling (FPWD) tool is run and used to acquire interference data while drilling. Initially reservoir pressures are acquired as soon as practically possible after drilling. Having established these benchmark pressures, nearby injectors and/or producers can be started or shut in one at a time. Drilling is then resumed and after a certain time has elapsed since the benchmark pressure acquisition (typically at least 12 hours), the pressure measurements are repeated using the FPWD tool to evaluate the influence of the created transients in order to prove or disprove either lateral or vertical hydraulic connectivity across reservoirs. This way, the influence of a single offset well is evaluated in real time over the reservoir being currently drilled. This helps in the determination of interference pattern whereby injector wells can be judged for selective zone injections and producers can be rated in terms of zonal contribution which can help in completion design.

These direct pressure measurements can illuminate reservoir pressure complexity seen in mature fields and provide operators with the means to safely and effectively construct wells to develop brownfields. The pressure changes obtained are used not only by reservoir engineers as an additional source of dynamic data into the reservoir simulation model but also help geologists in refining the geological or basin model.

Two applications of real-time interference testing using FPWD from a recent drilling campaign are shown. In the first application, communication between wells is tested to reduce the risk of accidentally completing a well in an area of the field that experiences insufficient injection support. In the second application, real-time interference testing is used to identify a specific zone in a multi-layered reservoir sequence in order to enable selective completion.



Sequence of events and Pressure Survey results

Yon Blanco is a Principal Reservoir Engineer currently supporting the LWD reservoir portfolio in the Eastern hemisphere located in Bucharest, Romania. He joined Schlumberger in 1994 and has held several positions in field operations, Technology Center and Operations support for both Wireline and Drilling & Measurement.

Successful Application of Formation Tester 10K psi Sensor Technology in Obtaining Reliable Pressure Measurements with Reduced Rig Time in Caspian Region

Objectives/Scope: One of the major operators in Caspian West started drilling appraisal wells in gas-condensate field in which control over formation and well stability needed to be addressed through formation pressure measurements in low permeability and low mobility heterogeneous sand layers with a total depth of 6-7km with high differential pressure (approximately 6200-7500 psi). Since the standard rated formation pressure testers with maximum of 6000 psi drawdown were not designed to show enough drawdown, buildup, and stabilization, Halliburton Sperry team offered 10K PSI (drawdown capacity) GeoTap® formation pressure tester technology to the customer to meet the objectives of this specific job successfully.

Methods, Procedures, Process: At the request of the customer 10kpsi GeoTap® testing was utilized in the Caspian West and all of them were interpreted to be good tests with acceptable buildup stability and pressure repeats. The process was run by total automatic test control and auto-selected pre-test volumes including selection of variable drawdown rates, buildup times, and test interruption via Geo-Span downlink service. High resolution test data was transmitted via Replay® Real Time service and INSITE® rig information management system for real-time data analysis. At each of the tests obtained type curve matching methodology is used to measure how closely the data conforms the exact model by calculating the standard deviation of the data from theoretical curve.

Results, Observations, conclusions: The improved GeoTap® sensor technology made it possible to obtain real-time, direct pore pressure measurements with accuracy and precision comparable to that of wireline formation testers the GeoTap® 10K PSI sensor technology, but with less risk and lower cost. Saving time and money by reducing rig down time associated with wireline testing made GeoTap® unique solution as pressure-while-drilling services. By meeting operator expectations, GeoTap® 10K PSI sensor technology resulted on delivery of the good quality pressure measurements, drawdowns, buildups, and mobility calculations for reservoir characterization and management purposes in such challenging subsurface conditions and reduced rig time by eliminating the need for wireline operations, saving one-two days of rig time worth approximately USD 1 million.

Novel/Additive Information: Customer challenges were successfully addressed through improved formation evaluation, fluid contact points determinations, reservoir connectivity/ compartmentalization, and depletion analyses using 10K GeoTap® Technology by Halliburton.

Speaker bio: Elnur Amirov is a Sr. Tech Prof Sperry Petrophysicist/LQC/SE TL and has been working at Halliburton full-time for many years. He received his master's degree from Middle East Technical University and graduated with honors before eventually becoming PhD at the Geology Institute of the Azerbaijan National Academy of Sciences. He was also Professor at the Department of Petroleum Engineering (Khazar University and Baku Higher Oil School) and taught to students "Well Logging", "Formation Evaluation" and "Drilling Engineering" for several years. Performed more than 50 presentations related with LWD Tools, Formation Evaluation, Formation Tester, Log Quality Control and organized several SPE & ASPG seminars/events/knowledge sharing sessions for members and students in UFAZ (The Azerbaijan-French University), BHOS (Baku Higher Oil School), Khazar University, BSU (Baku State University), ASOIU (Azerbaijan State Oil and Industry University). This seminar/presentation at LPS will be dedicated to the memory of Amirov's father, Professor/Academician Fikret Alibaba Amirov.

Optimizing Fluid Scanning & Sampling Success in Unconsolidated Formations While Drilling

Marcus Turner, Scott Paul, Alex Dykes Schlumberger

Assessing reservoir fluid composition in real time, while drilling, is becoming a more common practice. The clear advantage of being able to sample while drilling significantly reduces operational risks, coupled with the short time after bit typically reduces the depth of invasion impacting clean up times compared to Wireline conveyance particularly in deviated wells. This has opened a wide range of opportunities for operators to sample fluids in wells with complex trajectories; However, despite the fact that sampling and performing downhole fluid analysis while drilling poses significant advantages compared to wireline, there are some technical restrictions that limit the applicability of such technology. The limited availability of probe size and shapes compared to Wireline, many represent an issue when planning to scan or sample fluids in unconsolidated formations, where the risk of mobilizing formation fines and hence plugging the tool may result in an unplanned POOH to change the sampling tool.

However, a holistic approach, based on a combination of optimized sampling tool hardware, bit hydraulics, petrophysical evaluation, granulometry evaluation and pretest mobility analysis, has resulted in a new workflow that can significantly reduce the risks of deploying fluid scanning and sampling technologies into unconsolidated Sandstone environments.

This paper discusses a novel methodology that can be used to maximize success in scanning and sampling formation fluids when Formation Mapping While Drilling (FMWD) technology is used in real time, whilst drilling unconsolidated formations. The methodology is based on a solid workflow built on experience garnered and captured in various operations and studies performed around the world.

The methodology is based on four pillars:

I. Predicting, assessing and confirming potential fines migration and formation collapse while FMWD are ongoing. The analysis is based on the processing and interpretation of existing data from offset wells and real-time newly acquired sonic and/or density data.
II. Design FMWD operations such that formation sanding is prevented, and formation integrity is maintained.
III. If partial formation collapsing occurs, prevent mobilized fines from entering the FMWD tool.
IV. If fines enter the tool, then the workflow focuses on reducing the negative impact of these solids on the flowline, pump out and optical analyzers.

Speaker Bio

Marcus Turner is the Principal Regional Reservoir Domain for the Drilling Group covering Africa, providing technical support for Formation Pressure and Sampling While Drilling operations.

He has 27 years of Oil & Gas industry experience covering Mudlogging, LWD, Drilling Optimization, Directional Drilling, Drilling Engineering and Reservoir Domain positions. Working internationally throughout his career, obtaining experience in a spectrum of environments, from Deep Water exploration through to land operations, in North and Sub-Sahara Africa, Europe, Middle East, US, North and South America.

Since 2005 he has been involved in the design and development of Formation Pressure While Drilling (FPWD) and Formation Sampling While Drilling (FSWD) technologies within Schlumberger which brought him into the Reservoir Domain in 2007. He has been the technical focal point for Sub Saharan Africa since 2009, with occasional forays into North Africa.

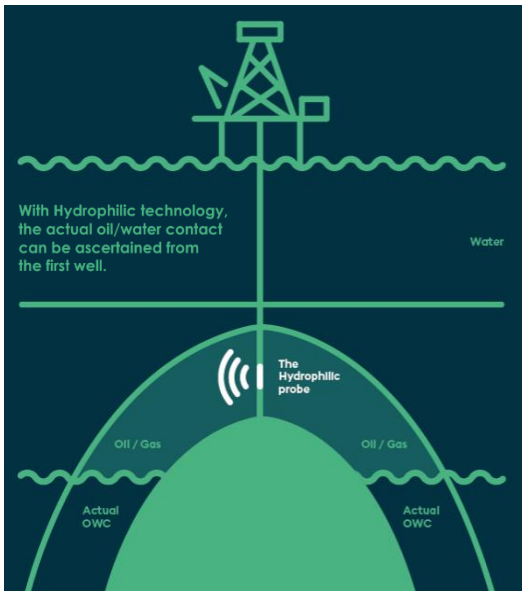
The Prototype Hydrophilic Logging Tool (HLT)

The HLT is a new wireline tool that shall provide significantly more efficient appraisal of hydrocarbon discoveries. A single depth measurement with the HLT will be enough to calculate the depth to the FWL (Free Water Level).

Just when some thought that exploration for oil and gas was about to become a thing of the past we now seem instead to be heading into a new bonanza for the E&P industry. The development of the HLT has taken approximately five years. That is one more than we thought at the start. However, the need for the technology has not declined. Fast, efficient, and more environmentally friendly appraisal of new discoveries are more in demand than ever before.

The presentation will explain the fundamental physical principles behind the technology and show how the idea was born. Some "everyday" examples of the implications of the physics will be given together with lab and workshop test results.

The unique pressure signature from the probe will be shown and explained. The prototype HLT is now almost ready for offshore pilot testing, and we are excited to give an update on the status of technology development.



Pictures and videos from the lab, workshop and onshore operational demonstration will be shown.

Trond Rolfsvåg: born in Bergen, Norway in 1963. MSc in Reservoir Engineering from University of Stavanger (1988). Founder and CEO of Hydrophilic. Worked for NORCE (1986-90), twice for NPD (1989 & 2017), Equinor (1990-95) and ConocoPhillips (1996-2016). Since 2018 full time for Hydrophilic.