London Petrophysical Society (a chapter of the SPWLA)
One-day Seminar

"DRILLING-101: *Everything a Geoscientist needs to know about Well Engineering but was afraid to ask*"

25th September 2014
The Geological Society, Burlington House, London.

This is the latest in our line of "Basic FE" seminars, and is intended as an introduction to Well Engineering for Petrophysicists and other Geoscientists. This one-day seminar will provide a basic understanding and vocabulary for professionals from a wide-variety of backgrounds and it should work to improve the way we can work together as a team to achieve safe and successful wells.

Agenda

start	*end*	*Topic*	*Presenter*	*Company*
09:00	*09:15*	*Registration*		
09:15	*09:30*	*Introductions*		
09:30	10:10	A quick tour around a drilling rig - an introduction to the basic functions	Mike Millar	
10:10	10:50	Well Planning	Katiuska Borjas	BG Group
10:50	*11:10*	*Break*		
11:10	11:50	Drilling bits	Thorsten Schwefe	BakerHughes
11:50	12:30	Drilling fluids and the circulation system	Iain Scott	MI Swaco (Schlumberger)
12:30	*13:20*	*Lunch*		
13:20	14:00	Directional drilling	Peter Dadswell	BakerHughes
14:00	14:40	Casing, Liners and completions	Mark Blennerhassett	BakerHughes
14:40	*15:00*	*Break*		
15:00	15:40	How zonal isolation is provided from the wellhead to the production zone	Debbie McIntosh	otm Consulting
15:40	16:20	The Science of Mud Logging in Drilling	Femi Tanimola	Geoservices (Schlumberger)
16:20	17:00	Formation evaluation through core data acquisition - a technical overview	Jean-Valery Garcia	Corpro, ALS Oil & Gas
17:00	17:15	Wrap-up, including Implications for Formation Evaluation	Mike Millar	
17:15		*Wine and Savouries*		

A Quick Tour Around a Drilling Rig - an introduction to the basic functions

It is important to know why are we drilling a well as different types of objectives will lead to different types of borehole with the associated planning challenges. For an exploration or appraisal well, we want to know if there is any oil or gas down there, where is it (depth/location), how much is there, and whether we can get it out safely and make any money? For development and production drilling, we are planning to make a safe and cost effective conduit between the reservoir and the surface facilities. This can be to produce hydrocarbons, or to inject fluids to maintain pressure and ensure sweep efficiency, or it can be to monitor fluid levels, or dispose of unwanted fluids and/or solids. Safety should be at the forefront of all our decisions in planning and executing a borehole.

Most drilling rigs are made of the same basic structure and components such as, a derrick to allow the drill pipe to go in and out of the well, drill pipe with a drilling bit at the end, power to turn the drill-pipe, pits for drilling fluid, space for stores, drill pipe, generators, accommodation, offices, workshops and some sort of access.

The derrick is a tower-like structure which supports the equipment used for lifting and positioning the drilling string above the borehole, and it contains the machinery for turning the drill bit around in the hole. It needs to be tall enough to allow new sections of drill pipe to be added to the drill string as drilling progresses. The derrick also controls the weight on the bit (WOB), important because the rate of penetration is maximised with the optimum weight on bit.

The substructure is an assembly used to elevate the derrick and provide space underneath to install the blowout preventer, casing head, and other equipment. The monkeyboard is a small platform high up in the derrick that the derrick man stands on when tripping pipe.

The drill floor is located directly under the derrick and is the work area in which the rig crew conducts operations, usually adding or removing drillpipe to or from the drillstring. The drilling console is the control panel, where the driller controls drilling operations. They have instruments to monitor Mud pumps, WOB, ROP, RPM, Torque etc. Next to the rig floor is a small metal room, the doghouse, where the rig crew can meet, take breaks and take refuge from the elements during idle times.

The drill pipe is made of steel tubing and is used to turn the drill bit and circulate the drilling fluid (mud). Each section of drill pipe is 30 feet long (API standard) and is fastened together by means of threaded joints. Drill pipe can vary by external diameter to suit the planned hole size and by the thickness and quality of the steel to suit the conditions expected when drilling the well. A stand is usually three (but could be two or four) single joints of drillpipe that remain screwed together during tripping operations. Unused stands stand upright in the derrick.

The bottom hole assembly (BHA) is at the bottom part of the drillstring and generally consists of the bit, stabilizers, drill collars, heavy-weight drillpipe and jars (to help free stuck pipe). The BHA helps to provide the force for the bit to cut through the rock (WOB, torque). It needs to be robust enough to survive the hostile environment and provide the driller with directional control of the well. The BHA may also include a mud motor, directional drilling equipment, directional survey equipment and logging-while-drilling tools.

The drill pipe and the BHA combine to make up the drill string. The drill string is hollow so that mud can be pumped down through it and circulated back up the annulus (the void between the drill string and the casing/open hole).

The rig needs a power supply, usually large diesel, fuel-oil or gas engines, often powering electrical generators. These drive the hoisting system and the rotating system, as well as ancillary equipment, lighting and heating, etc.

The hoisting system is used mainly to move the drill string. It consists of a mechanical winch called the drawworks, which lets out and pulls in the steel cable called drilling line.

The drilling line is reeled over the crown block and traveling block in a block and tackle fashion. This reeling out and in of the drilling line causes the traveling block, and thus the drill string, to be lowered into or raised out of the borehole.

The crown block is an assembly of sheaves or pulleys fixed on beams at the top of the derrick. The drilling line is run over the sheaves down to the draw works. The traveling block is an arrangement of pulleys or sheaves which moves up or down in the derrick, threaded back to the stationary crown block located on the top of the derrick through the drilling line. This enables the drill string or casing and liners to be lifted in or out of the borehole.

The swivel is a mechanical device that suspends the weight of the drill string allowing it to rotate, while the travelling block etc. above doesn't rotate. It also allows the flow of drilling mud from the standpipe into the drill string.

The rotary system is used to turn the drill string and thus the bit. There are essentially three ways of turning the bit, down-hole mud motors, the top-drive and the rotary table / kelly.

Rotary table - kelly drilling, the rotary table is a revolving section of the drill floor that provides power to turn the drill string in a clockwise direction (to the right, as viewed from above). The rotary motion and power are transmitted through the kelly bushing and the kelly to the drill string. Most rigs today have a rotary table, either as primary or backup system for rotating the drill string.

The kelly is a square or hexagonal steel tube suspended from the swivel, which passes through the kelly bushing on the rotary table and is connected to the top of drill string to turn the drill pipe as the rotary table turns. The kelly is used to transmit rotary motion from the rotary table or kelly bushing to the drill string, while allowing the drill string to be lowered or raised during rotation.

Depth measurements are commonly referenced to KBE - kelly bushing elevation, or RTE - rotary table elevation, or DFE - drill floor elevation

The topdrive is a motor that is suspended from the derrick and is an alternative to the traditional rotary table / kelly drive. A top drive has one or more electric or hydraulic motors, which is connected to the drill string . Suspended from a hook below the traveling block, the top drive is able to move up and down the derrick. This allows drilling to be done with three joint stands instead of single joints of pipe. It also enables the driller to engage the pumps more quickly when tripping pipe in or out of the hole, than can be done with the kelly system. Top drive drilling can be largely automated, making drilling a safer and more reliable process

The drilling bit is the cutting device attached to the bottom of the drill pipe and its function is to perform the actual cutting or drilling of the rock formations. Everything on a drilling rig directly or indirectly assists the bit in crushing or cutting the rock. The bit must be changed when it becomes degraded and stops making reasonable progress. Most bits work by scraping or crushing the rock, or both, usually as part of a rotational motion.

The bit consists of rock cutting elements and fluid circulating elements. The bit nozzles allow the circulation of drilling mud from the drill string into the annulus. The hydraulic force of the mud can improve drilling rates, as well as cleaning and lubricating the bit, and circulate cuttings out of the hole. Bits come in many shapes, sizes and materials (tungsten carbide steel, diamond) and are specialized for various drilling tasks and different rock types.

The circulation system allows the flow of drilling mud from the surface mud pits, down through the drill string, out into annulus via the bit and returning to the surface via the annulus. It is critical to well control and for safe and efficient drilling. Drilling fluid - mud, is a mixture of a base liquid (often water or oil), solids (such as clay), weighting materials and chemicals.

The standpipe is a rigid metal conduit that provides the pathway for drilling mud to travel about one-third of the way up the derrick, where it connects to a flexible hose and thus to the swivel. The rotary hose is high-pressure flexible line used to connect the standpipe to the swivel. This flexible hose allows the whole drillstring to be raised or lowered while mud is pumped through it. The gooseneck is a section of rigid piping that connects the top of the standpipe to rotary hose that in turn is connected to another gooseneck on the swivel.

A blowout is the uncontrolled flow of formation fluids from borehole to the environment. The blowout preventer (BOP) is designed to safely control such pressures and to stop the flow to the surface. The BOP consists of high-pressure valves (located under the drill floor on land or on the sea floor) that seal the high-pressure drill lines and relieve pressure when necessary to prevent a blowout. By activating the BOP (usually remotely via hydraulic actuators), the crew can usually regain control of the well, and procedures can then be initiated to increase the mud weight until it is possible to open the BOP and retain control of the formation.

BOPs come in a number of styles, sizes and pressure ratings. Some can effectively close over an open borehole, some are designed to seal around tubular components in the well (drillpipe or casing) and others are fitted with hardened steel shearing surfaces that can actually cut through the drillpipe and/or casing. Since BOPs are fundamentally important to the safety of the crew, the rig and the borehole, BOPs are inspected, tested and refurbished at regular intervals determined by a combination of risk assessment, good practice, well type and legal requirements. BOP tests vary from daily function testing on critical wells to monthly or less frequent testing on wells thought to have low probability of well control problems.

Casing and liners are steel pipes that are cemented into the hole to line the borehole wall. These fulfil a number of tasks such as, preventing the hole from collapsing, protecting shallower formations from fluids and pressures of deeper formations, and maintaining drilling mud circulation and thus maintain well control.

Rig types - where you want to drill and how deep you want to go will determine which type of rig you need for your well. A shallow onshore water well can be drilled from a rig on the back of a truck, drilling to 17,000ft in an HPHT environment offshore might need a heavy duty jack-up, and 2,000m water depth will need a dynamically positioned drill-ship. Offshore rigs are generally tighter for space, and access is more difficult, by boat and helicopter. They also need a riser to connect seabed to drill floor to allow circulation. Jack-up rigs are used in water between 10 to 120 metres, the legs are jacked up when moving the rig and jacked down when on site. Semi-submersibles sit above large pontoons which are ballasted below the surface waves to maintain buoyancy and stability. Drill ships and semi-subs are held in position by anchors or computer controlled thrusters (dynamic positioning).

With thanks to many sources including;

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http://www.fesaus.org/glossary/doku.php
http://www.conservation.ca.gov/dog/picture_a_well/Pages/qh_well.aspx
https://www.osha.gov/SLTC/etools/oilandgas/illustrated_glossary.html

Well Planning

Katiuska Borjas - Lead Well Engineer - BG Group

The Well planning process involves many variables. These include integration of different engineering principles, complying with industry standards, managing complex logistics and using input from several other disciplines. The main objective is to drill the well safely within a defined budget that delivers the well objectives. The objectives for each well depend on the maturity of the field.

Exploration wells can be data intensive where subsurface uncertainty is high so evaluating reservoir quality and the presence of hydrocarbons is important. Appraisal wells are also data intensive but may include additional activities such as coring and welltesting. This will guide the commercial decision whether it is feasible to progress the project. Finally Development wells main objective is to put the field on production but this may have its inherent challenges.

A well planning engineer will use data (formation tops, total depth criteria, pore pressure and fracture gradient data, lithology column, potential hazards,etc) provided by our Subsurface colleagues to ensure the well is designed to a high safety standard by mitigating potential hazards using offset wells data and engineering tools available.

Directional Drilling

Peter Dadswell – Executive Account Director, Baker Hughes, London

Directional Drilling – this session will review the multiple reasons for drilling directional wells and the variety of technologies and techniques employed by the directional driller to ensure the wellpath intersects the well targets. We will cover the borehole survey requirements, the various rotary assembly BHA types, steerable drilling motors and the latest Rotary Steerable Systems, discussing the benefits and limitations of each.

How zonal isolation is provided from the wellhead to the production zone

Debbie McIntosh CEng MEng - OTM Consulting, a division of Sagentia Group plc.

There have been a number of well documented events in the industry where the lack of zonal isolation has resulted in gas migration, blow outs, or the catastrophic loss of an asset. Many of these risks can be mitigated through careful selection and installation of the wellhead, casing strings and cementing operation tailored to the particular downhole conditions.

There is no single solution for all wells. This presentation will provide an overview and explanation of the typical formations cased detail the main challenges and how the industry is working to overcome them. It will introduce the main components of a wellhead, key features of the casing and tubing strings and how they are installed (Figure 2) and their purposes. Safety features and regulations will be introduced, highlighting differences between regions.

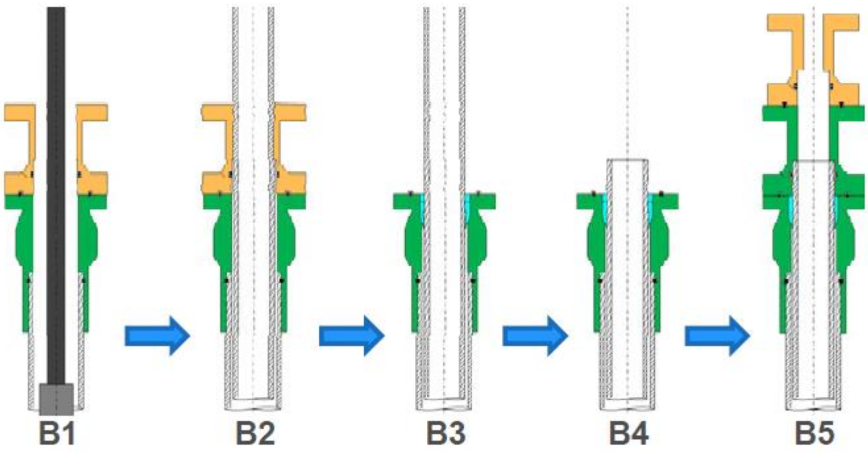

Figure 1: Simplified illustration of the installation process for a spool type wellhead

Following the introduction of the main components and features within the main wellbore, the considerations for the cementing operation will then be discussed with an overview of the role of cement bond logs in the QC of cement. A typical cementing operation design process is shown in Figure 2, with the presentation providing a brief introduction to each stage of this process to ensure a good cement job and resultant zonal isolation is maintained.

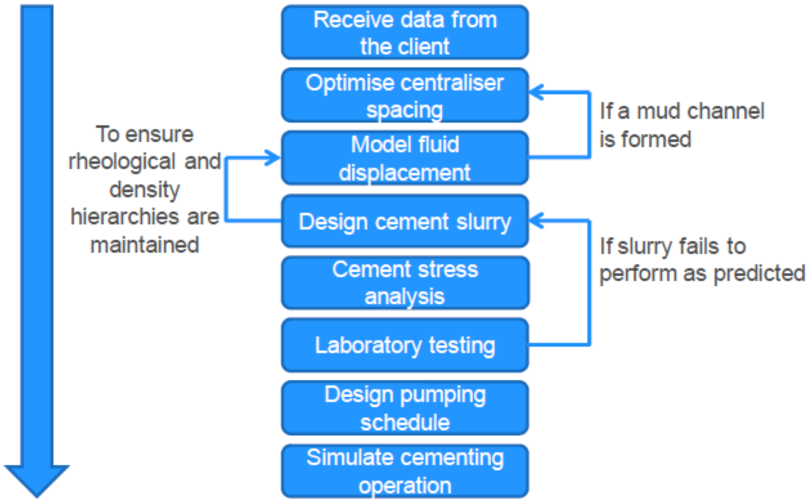

Figure 2: Typical design method for a cementing operation

The Science of Mud Logging in Drilling

Femi Tanimola, Geoservices, a Schlumberger Company

Mud Logging is the process of monitoring and analysing changes in characteristics and contents of the fluid used in drilling operations (generally a water or oil based solution, defined as “mud”. Air, foam, or Nitrogen gas could also be employed as alternatives), as it returns to surface during the drilling operation in order to generate interpretative borehole logs called Mud Logs.

The Mud or Master Log is perhaps the earliest form of reconstruction of the well stratigraphy, created in near real time while drilling. Expectedly, Mud Logging is synonymous with providing a view of borehole subsurface information, and simultaneously giving an indication of safety issues encountered during the drilling operation.

Mud Logging today consists in observation, monitoring, analysis and reporting in log form, & other datasets of the nature, interrelationship & character of the subsurface geology and the fluid content of the drilled rocks porosity as is observable on surface with the use of data acquisition sensors and highly sophisticated hydrocarbon gas analysers.

In gathering information about the subsurface, many physical parameters pertaining to every aspect of the drilling operation, the sequence of operation of the drilling rig and its ancillary equipment are carefully measured and recorded by means of surface sensor positioned around the drilling rig. This drilling data is factored into Mud logging data interpretation carried out at the Wellsite.

Mud Logging is also sometimes referred to as Surface Logging because all the Mud Logging sensors are located on surface, relative to the environment being observed, in the borehole. The engineers who perform the work are called Mud Loggers and the portable Wellsite laboratory where all their work is carried out is called a Mud Logging Unit.

This paper discusses various aspects of Mud Logging service, primarily Formation Evaluation, Drilling Performance Optimisation and Wellbore Stability as they affect the safe, efficient and economic exploitation of hydrocarbon.

Formation Evaluation through core data acquisition

JV Garcia, ALS Corpro

Only from the core you can obtain direct measurement of the main Petrophysics reservoir characteristics. All other means of evaluation are either calculated or extrapolated. Only the core will provide “rock solid” evidence!

This presentation review the basic of coring with all associated surface handling services which will lead to the success of your formation evaluation program.

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