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Wireline Data Acquisition under Managed Pressure and Pressurized Mud Cap Drilling Condition – Pushing the Boundaries of Data Acquisition Envelop for Formation Evaluation

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Abstract

There is a perception that conventional wireline logging operation in Managed Pressure Drilling (MPD) and Pressurised Mud Cap Drilling (PMCD) conditions is not feasible due to HSE risks associated with the operation. Rigging up a wireline assembly and safely performing the job while the well is experiencing total or partial loss circulation or potential gas migration is extremely challenging with currently available technology. However, with the new comprehensive technology, described in this paper, these challenges can be mitigated enabling acquisition of all desired formation evaluation data.

MPD and PMCD techniques, with close loop adjustable back pressure, have gained wide acceptance. This is owed to the current market demand of drilling deep-water wells, with narrow mud windows and in fractured reservoirs, under total or partial loss conditions, safely and with optimum cost. To reduce the drilling risk, relatively simple drilling bottom hole assembly (BHA), with limited logging while drilling (LWD) tools, are preferred in such conditions. A new technological solution is desired to acquire complete formation evaluation data, on wireline, after drilling. Wireline well logging under this condition requires a non-standard and complex rig up, especially in the floater, to allow the operation to be performed safely but efficiently. With the new development of Managed Pressure Logging System (MPLS), an integration of Smart Sub System, and Grease Injection System, wireline operation can now be performed safely in active MPD/PMCD conditions.

The newly developed smart sub, discussed in this paper, features an innovative system available for multiple operations including MPD/PMCD wireline logging. It provides the sought-after well control mechanism which allows wireline operations, through a side entry, without interfering with drilling rig's top drive system. The unique design of the sub is compatible with all industry-recognized grease injection and pack off systems used to maintain the desired pressure in the wellbore. When deployed with active PMCD condition, it creates a closed-loop system to enable the driller to continuously pump drilling fluid and adjust borehole pressure during wireline logging. This paper discusses the complete operational detail of a number of wireline logging operations performed in a deep-water well under MPD/PMCD condition. This includes planning, associated challenges, deployment risk assessment, standard operating procedure,

and mitigation plan. The paper also incorporates standard data acquisition practices, results, lessons learned, and recommendations.

This comprehensive workflow of wireline logging, with MPD/PMCD technique, and under total or partial loss condition, using the smart sub, pushes the wireline operating boundaries of data acquisition for formation evaluation, to places previously thought to be not feasible. This new solution has the potential to solve other challenging wireline deployments application including pipe recovery, pressurized cement bond evaluation and overbalance wireline perforation.

Introduction

PMCD, a variant of MPD, is a technique that allows a well to drill to total depth (TD) in total loss circulation condition with a process to counter any potential influx of reservoir fluid. The PMCD technique is typically used in drilling carbonate reservoirs with huge karst or connected fractures, deep-water wells with narrow mud window, and fracture basements. The PMCD operation creates a near balanced condition by injecting Light Annular Mud (LAM) in the sealed annulus. The operational complexity, deployment risk associated with activated PMCD setup and the dynamic condition of the borehole due to the absence of mud cake at near balanced condition often results in an unfavorable condition for wireline open-hole logging. Due to these risks, the wireline open-hole logging is commonly not considered as a safe method to acquire formation evaluation data in this condition

In this paper, we will discuss the newly developed Managed Pressure Logging System (MPLS), which is a combination of Smart Sub and Grease Injection System, and how this enables safe wireline operation in active MPD/PMCD conditions. This paper will outline prejob planning, steps to rig up & rig down, and the risk and mitigation plan associated with these steps along with detailed description of different components of the systems including Smart Sub with PMCD adaptor for wireline operation. It provides the sought-after well control mechanism that allows wireline operations, through a side entry, without interfering with the drilling rig's top drive system. This system was deployed successfully in a deepwater drill ship in Malaysia to acquire excellent quality wireline data for formation evaluation of a fractured carbonate reservoir.

Wireline Logging Challenges in MPD/PMCD Mode

The main challenge for wireline tool deployment under PMCD mode is the inability of the Rotating Control Device (RCD) to seal on the cable and shut in the well throughout the logging operation. The RCD is designed to seal only on the drill string enabling the annulus to be closed at all times while the drilling commences normally. Even though wireline tools could be conveyed on drill pipe, part of the cable that is above side entry sub would still be exposed, preventing proper sealing at the RCD. In fact, there is a high possibility of cutting the cable at the RCD due to friction. Additionally, the wireline is made of an external armor and internal structure with space in between and has a potential risk of seal failure when applying pressure. The absence of a pipe at the hole also implies that LAM can not be injected to balance the pressure downhole as the well is drilled. This challenge requires modification to the wireline rig up process where some wireline pressure equipment is needed to be installed on top of the PMCD equipment to be able to log safely. This modified process not only takes a longer time to rig up and rig down but also possesses inherent HSE risk with the possibility of placing heavy pressure equipment on the rig floor.

Existing Practices of Wireline Logging in MPD/PMCD Set up

Two different approaches were used before as discussed in two papers by Kyi et. al., 2016 and Sales et. al., 2019. They used different techniques and equipments to mitigate the challenges discussed above. Below is a brief discussion on those process.

Kyi et. al. applied the customed MPD/PMCD wireline logging technique in a fractured carbonate well in the Sarawak basin of Malaysia. The wireline Pressure Control Equipment (PCE) was modified as illustrated in Figure 1. when logging under PMCD mode. The wireline PCE was connected to the RCD wireline logging adapter via a cross-over. A wireline dual pack-off assembly (pressure rated to 3000 psi) was installed on top of the shooting nipple to shut in the well. The dual pack-off assembly consisted of rubber elements and could seal around the wireline cables. The wireline PCE was required as part of the well barriers envelope to enable seawater to be continuously injected down the annulus to control the gas migration during wireline logging operations. While logging, LAM was continuously or intermittently injected down the annulus at a higher rate than the measured gas migration rate to control the gas migration. When the wireline tools were pulled above the blow-out preventer, the Blind Shear Rams (BSR) were closed and seawater was injected continuously at a higher flow rate than the apparent gas migration rate into the wellbore below the BSR via kill line. This was to ensure all the formation gas was bullheaded back into the formation.

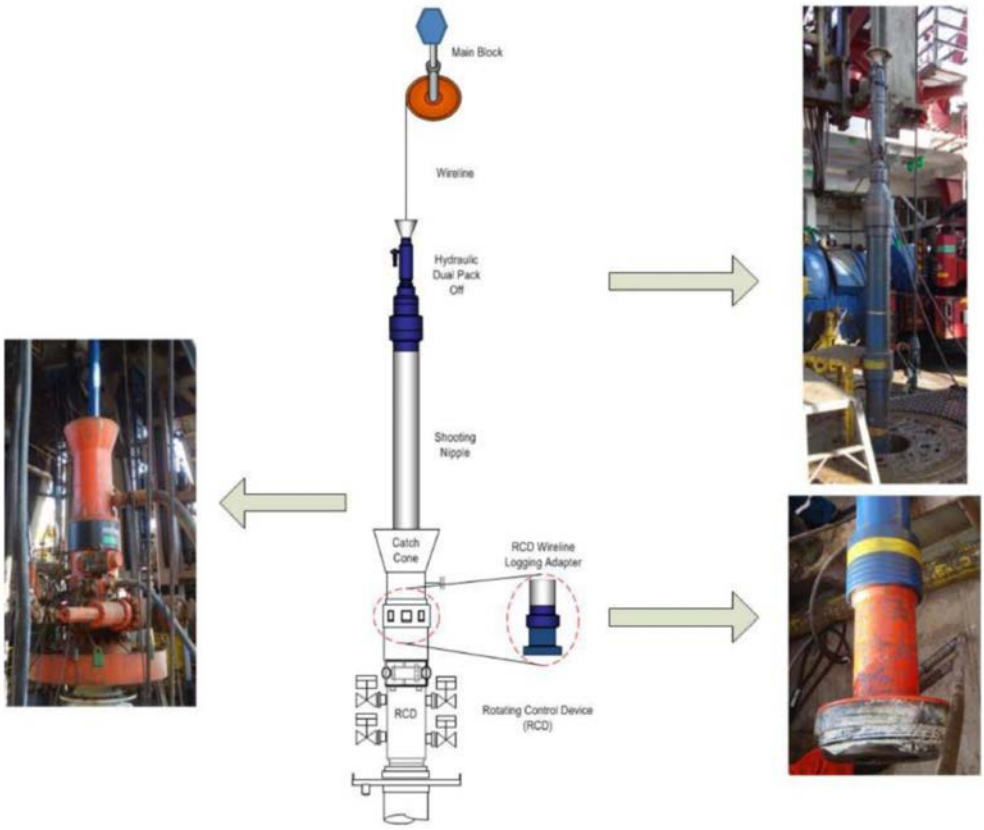

Figure 1—The set up used by Key et. al. 2016. It shows the equipment rig up for wireline logging in PMCD conditions. RCD wireline logging adaptor installed on the RCD adssembly and connected to shooting nipple via crossover provided close conduit to the rig floor for the installation of wireline pressure control equipment (dual pack off). After Key et. al., 2016

There were few risks associated with this approach. This system uses basic pressure control equipment involving rubber element pack off and shooting nipple, which is unable to seal the wellbore completely during the cable movement while taking the tool in or out of the well. Additionally, this system does not provide proper depth compensation in measurement; hence not suitable for drillships, tender or semi-sub rigs where this can be critical. The tool string length can also be limited in this approach due to inadequate space for tool makeup.

In 2019, Sales et al. took a different approach to overcome the earlier limitations. This method was applied in a DP rig to drill a well in vaggular and fractured heterogeneous carbonate reservoir in the Santos basin of Brasil. A stuffing box or a lubricator were used to seal inner space within wireline cable. This equipment

allows grease to flow into the wireline armor and guarantees the seal. As the wireline logging tools could not pass through the lubricator, it was installed on the drill floor, allowing the tools to be run below the lubricator, with only the cable passing through it. The connection from the lubricator to the RCD (and logging adapter) was done using casing joints. Customized crossovers were designed and manufactured for the connections. Depth compensation was required, as the relative movement between the MPD riser joint and the rig was expected in the DP rig, since the RCD placed was below the tension ring and the lubricator was supported by the rig's equipment. A Coil Tubing Lifting Frame was used to compensate for the rig movement. It also provided a table at the base that made it possible to fit in the casing, helped to extend its size, eyepads to position the pulleys, a winch that would make it much easier to assemble the logging tools, and Pressure Control Equipment. To complete the surface assembly, a wireline BOP and quick test sub were added in case of a lubricator failure. The whole surface assembly is shown below in figure 3. Its components are 1) Snubbing/logging adapter that would allow to seal the annular with the same profile of the bearing sealing element used to drill; 2) An extension of casing from the logging adapter to the surface; 3) Pressure Control Equipment (PCE) with a lubricator and wireline BOP. This last one would allow the grease to seal in between the wireline armor; 4) Lifting Frame that allow the compensation of the assembly, normally used in coil tubing operations.

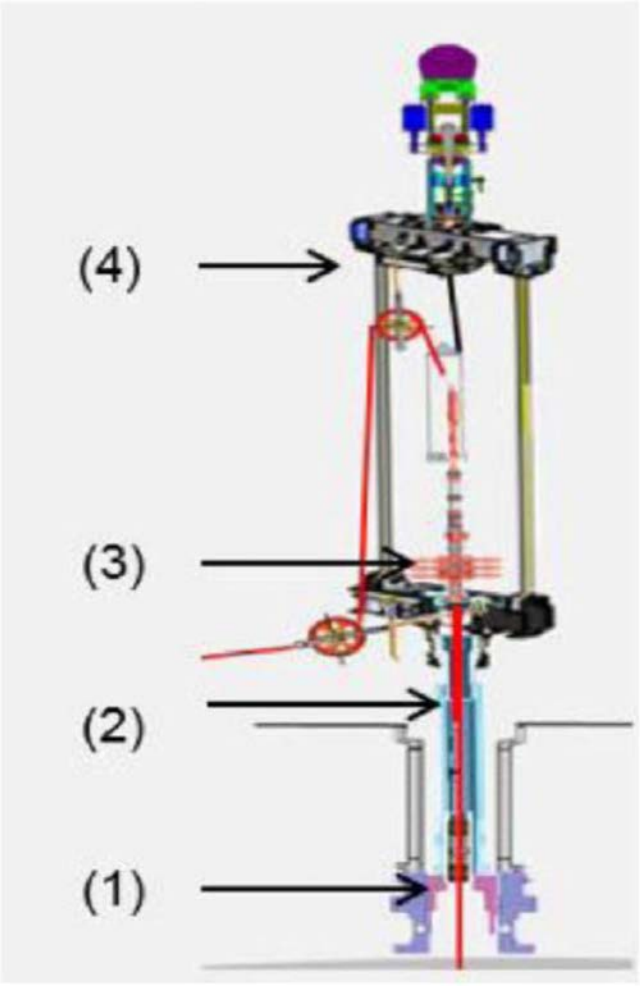

Figure 2—Surface assembly used by Sales et. al., 2019 1) Snubbing/logging adapter that would allow to seal the anular with the same profile of the bearing sealing element used to drill; 2) An extension of casing from the logging adapter to the surface; 3) Pressure Control Equipament (PCE) with a lubricator and wireline BOP. This last one would allow the grease to seal in between the wireline armor; 4) Lifting Frame that allow the compensation of the assembly, normaly used in coil tubing operations. After Sales et. al., 2019

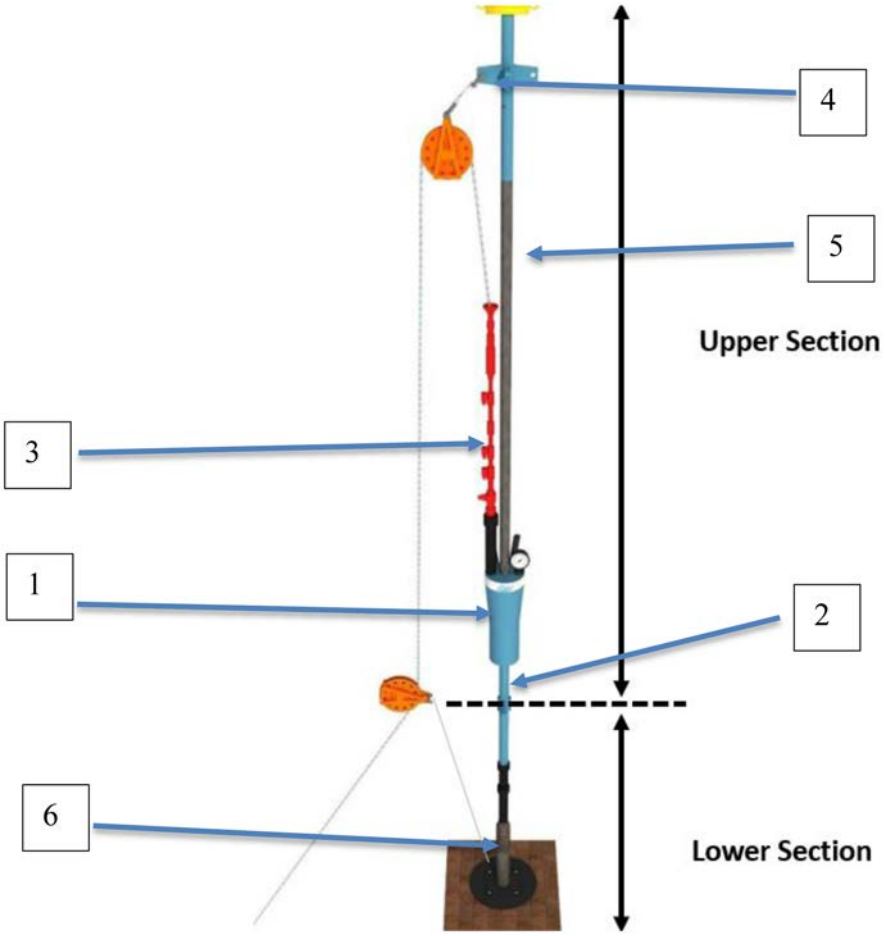

Figure 3—The newly developed Manage Pressure Logging System (MPLS) devide into 2 sections for rigup purposes viz., upper and lower. The sections are consist of 1) Smart Sub System 2) Swivel 3) Grease injection Head with Cable cutter 4) Pad eye sub 5) Drill Pipe pup joint 6) Casing Riser as marked in the figure.

The main difficulty with this technique is that the Lifting Frame (LF) is a large piece of equipment - heavy with large dimensions. It is also non-standard drilling or wireline equipment, which is additionally needed to be sourced and placed on the rig. It is indeed difficult to handle on the rig during a wireline operation due to its large size and requires specific equipment & trained personnel. Additional HSE risk associated with working on heights also needs to be assessed and mitigation processes needs to be planned. Although it can provide desired depth compensation and be able to contain the pressure during wireline movement with grease sealing, but the entire operational process is complex and involves number of procedures.

The New Smart and Comprehensive Manage Pressure Logging System (MPLS)

A new smart and compact but effective Manage Pressure Logging System (MPLS) is now developed to solve the wireline logging challenges in MPD/PMCD conditions as discussed earlier. This new system was designed to overcome the existing challenges and limitations discussed earlier.

Prejob-Planning & Risk assessment and Mitigation Plan

Since this was the first deployment of this newly developed MPLS technology, intensive pre-job planning was implemented to ensure the success of the operation. One of the biggest challenges was to understand the operational risk and limitations to formulate the detailed and systematic operational procedure. For this purpose, a thorough risk assessment was done using the Qualitative Risk Assessment (QRA) method, which

was specifically designed for MPLS. QRA not only evaluates the risk associated with HSE but also the risk related to the execution and quality of each task.

Few limitations were identified during this extensive planning process. Inability to perform reverse cut and thread fishing operation and limitation of wireline tool string length due to the maximum allowable size by the riser was extremely significant. A mitigation plan was put in place to address these limitations. Utilization of Deployment Risk Management tools viz., wireline Jar, Flywheel, High Strength Cable, and Mechanical Releasable Cable Head (MRCH) was deployed to minimize the risk of wireline tools getting stuck. Wireline data acquisition was split into multiple runs due to limitations related to the maximum allowable tool string length by the riser. Additionally, the current MPLS system design is limited by the maximum RCD logging adapter pressure rating, which was included as part of well control strategy. Furthermore, since the tools make up point is in between the riser joint, therefore the casing handling crew was needed to standby on the rig floor during wireline tool makeup operation. Finally, in the event of a cable birdcage, the current assembly required the surface well pressure to be zero prior to breaking any connection and fixing any cable birdcage. Therefore, it was critical to ensure no splice cable was used for this type of operation.

Deployment

Managed Pressure Logging System (MPLS), which is an integration of Smart Sub System and Grease Injection System had simplified the rig up process and operational procedure for wireline logging in PMCD. The MPLS system as in Figure 3 consists of 1) Smart Sub System as the primary component to allow the integration of all other key components; 2) Swivel to act as the point to allow riser break-off point for makeup and rig down logging tools; 3) Grease injection head with hydraulic cable cutter to maintain the dynamic cable seal during wireline logging and maintain the well pressure. The hydraulic cable cutter is chosen to be used as the primary option to cut the wireline cable in the event of an emergency; 4) Pad eye sub to act as the anchor point for the wireline top sheave for the wireline depth compensation during logging; 5) Pup joint to allow the system to connect with top drive system for full driller control and 6) Casing riser as the main lubricator for logging tools rig up and rig down.

The whole assembly can be divided into two major sections, viz., upper and lower section (refer to Figure 3), upper section consists of the upper pad eye sub, drill pipe, Smart Sub System, swivel, and grease injection head; whereas the lower section consists of risers and the RCD casing adaptor. During the rig up, the upper section was assembled first and necessary torque was applied to secure the connection. Wireline cable then was fed into the top sheave wheel, grease injection head, and to the bottom of the Smart Sub System. Only after that, the wireline cable head was connected. Once the necessary electrical check for the wireline cable head was completed, the upper assembly was racked back (Figure 4).

RCD bearing was then connected to the bottom of the risers (as shown in Figure 5). Once all riser connections were established, the lower section was secured on the rotary table using slips. At this stage RCD bearing location was approximately 5 ft above the RCD (not latched). Wireline logging tools were assembled inside the riser, section by section. Precisely selected tool clamps were used to ensure the logging tools were secured at the top of the riser while making the connection (Figure 6). Once all wireline tools were fully and securely connected, the wireline cable head was attached to the tool string and relevant tests were conducted to verify tool functionality.

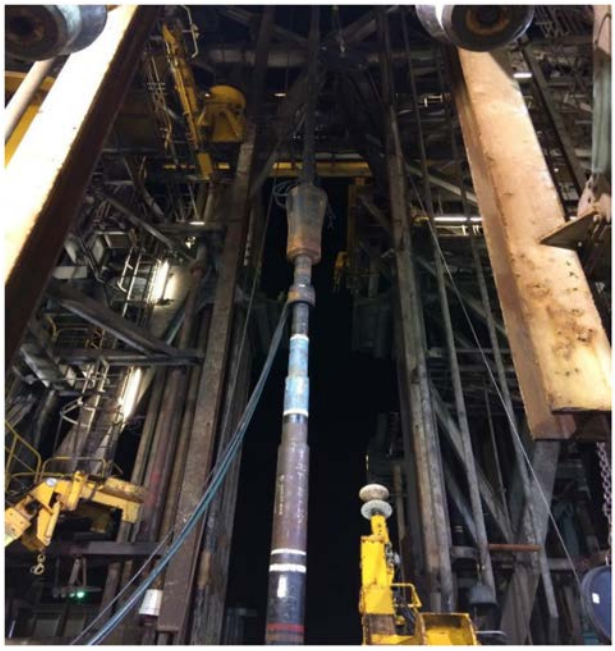

Figure 4—Photograph of the actual MPLS system - the upper section, control line for grease injection head is connected to control panel when the upper section were rack back to the derick.

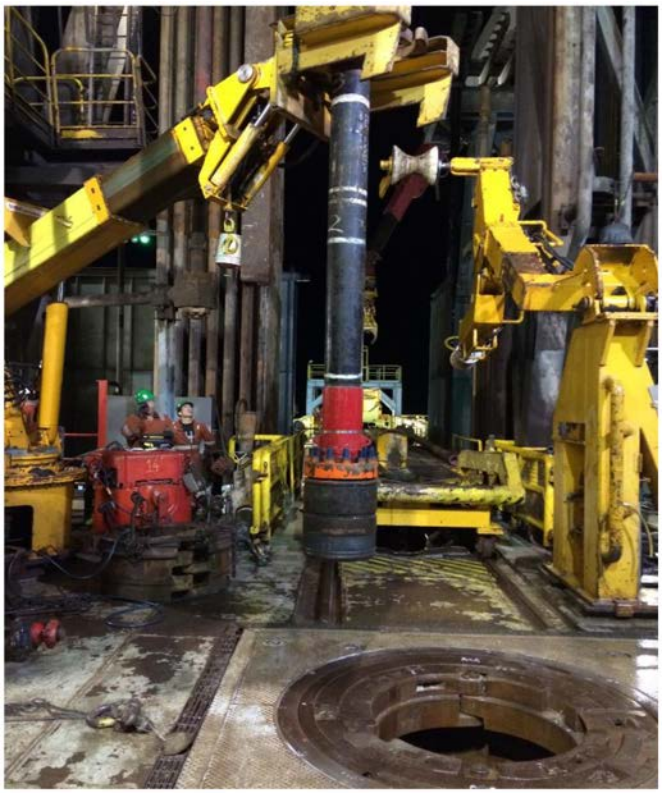

Figure 5—RCD bearing connected to the bottom of the riser.

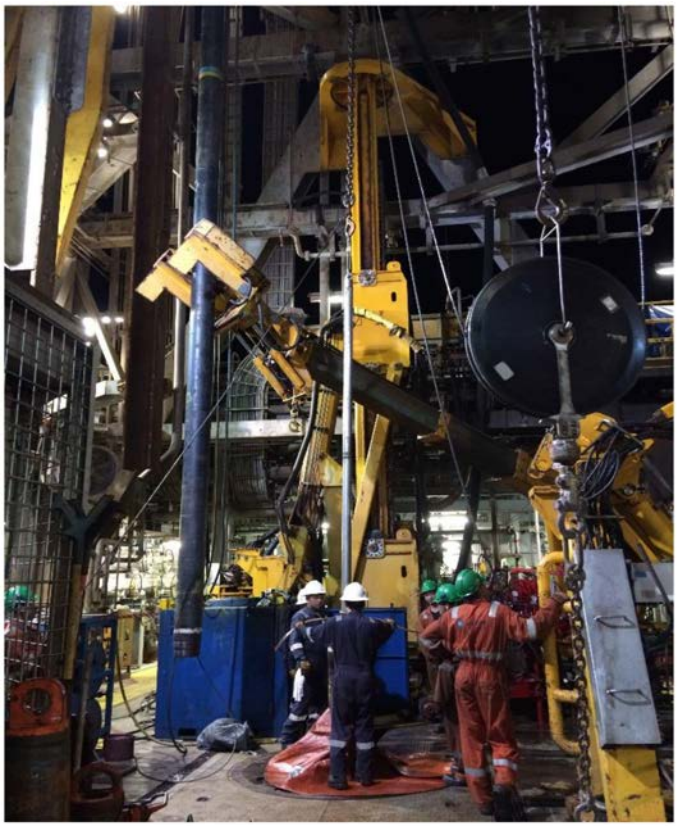

Figure 6—Wireline crew connecting wireline logging tool section by section inside the riser, rig tugger was used with caution to prevent damaging the riser thread.

After wireline tool checks were completed, the upper section was carefully connected to the top drive. When the top drive was lifting the upper section upward, the wireline winchman was simultaneously feeding the cable from the unit. The bottom of the upper section was then positioned approximately 5ft above the lower section. Once the wireline was secured to the bottom sheave wheel, the winchman finally picked up the tool string, removed the clamp, run in the tool string, and stop about 50ft below the rotary table. The final stage of the rig up was to connect the upper section to the bottom section and to latch into RCD. Swivel was extremely important at this stage to prevent the wireline wrapping on the surface when making the connection. Wireline operation was then resumed as per the normal procedure. Rig down procedure was exactly reverse to the rig up the process and followed sequentially to ensure safe and completion of logging operation. This efficient and safe rig up and rig down procedure with MPLS system reduced the Non Productive Time (NPT) substantially which was one of the major concerns in MPD/PMCD wireline logging in the past.

With this set up excellent quality cross dipole acoustic, Nuclear Magnetic Resonance (NMR), elemental spectroscopy, borehole image, rotary sidewall core, formation testing and sampling, borehole seismic data were successfully acquired to achieve all formation evaluation objectives. It helped the operator to effectively assess the potential of a deepwater carbonate reservoir.

As part of the continuous improvement and optimization, a unique quick connect is currently being developed to be placed in between the casing and the riser for easier make-up and rig up wireline logging tools in the future. Additionally, this new solution has the potential to solve other challenging wireline deployments application including pipe recovery, pressurized cement bond evaluation, and overbalance wireline perforation in similar challenging drilling environments in the future as part of the development plan.

Conclusion

The newly developed Managed Pressure Logging System (MPLS), integrating Smart Sub System and Grease Injection System was successfully designed and deployed in a drillship to acquire wireline openhole logs under MPD/PMCD condition in a deepwater well in Malaysia. With proper planning, equipment selection, pre-job preparation, risk assessment, and mitigation plan; good quality acoustic, Nuclear Magnetic Resonance, elemental spectroscopy, borehole image, rotary sidewall core, formation testing and sampling and borehole seismic data were successfully acquired in wireline to achieve all formation evaluation objectives to assess the potential of a deepwater carbonate reservoir. Detail and customized rig up and rig down processes was designed and successfully perfomed to achieve the safe logging operation. This portable and effective Smart Sub managed to seal the wellbore while allowing the wireline to move freely during the logging operation under the active PMCD mode. The unique design of the sub, which is compatible with all industry-recognized grease injection head and pack off systems used to maintain the desired pressure in the wellbore. The Smart Sub created a closed-loop system during active PMCD by allowing continuous injection of greese (at the greese injection head) to seal the wireline logging cable, while the RCD provided the necessery sealing on the casing riser. This enabled the driller to continuously pump drilling fluid and to adjust borehole pressure during wireline logging. The effective depth compensation of this system allowed this technology to be deployed in a drillship and has the larger potential to be deployed in all types of rigs. As part of the continuous improvement and optimization, a unique quick connect is being developed to be placed in between the casing and the riser for easier make-up and rig up wireline logging tools in the future. It will eliminate the risk of damaging the casing thread and also the need for a casing handling crew during the logging operations. This smart design and comprehensive workflow of wireline logging with MPD/PMCD, and under total or partial loss conditions, pushes the wireline operating boundaries of data acquisition for formation evaluation by providng the means to acquire quality log data in all types of rigs and safe and faster deployment which substantially reduces NPT.

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Reference

K. K.Kyi, K.Nathan, S.Haddad, W. WWa, A O KLee, and G. H. N.Hui, "New Developmenet in Wireline Logging Under Active Pressurised Mud_Cap Drilling Enabled Fractured Carbonates Evauation", OTC-26400-MS, Offshore Technology Conference Asia, Kuala Lumpur, Malaysia, 2016.

I. M.Sales, J. D. Sitonio Guedes, I. A. Martinello, T. C. L. Kropf, L M Caetano, A. A. Fernandes, and L. L. Sa, "Wireline Logging in Managed Pressure Drilling Well on a DP Rig", SPE/IADC-194542-MS, IADC/SPE Managed Pressure Drirring and Underbalanced Operation Conference and Exhibition Amsterdam, The Netherlands, 2019