CORETRACK

Practical Solutions - Innovative Technology

PRESENTATION: 2009 APPEA CONFERENCE & EXHIBITION

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Coretrack Limited ('Coretrack') advises that the following paper will be presented by the Company's Technology Manager, Mr Greg Wheatley, at the Australian Petroleum Production & Exploration Association's 2009 Conference and Exhibition, scheduled to be held in Darwin from 31 May 2009 to 3 June 2009.

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MWC™ - Measurement While Coring

Coretrack Limited is an ASX listed company which provides leading *technological solutions* to the global oil & gas industry. Coretrack's primary focus since listing has been the commercialisation of its revolutionary and patented technology, the Core Level Recorder System.

The Core Level Recorder (CLR) is a measuring and recording device that is placed inside the inner core barrel. During coring the unit rests upon the column of core that is entering the barrel and records the amount of core captured. This data collected will inform geologists from what depths core was captured and conversely, where core was lost, if a full recovery was not obtained. Coretrack has run the CLR (without the telemetry to surface) with a number of major operators & the tool is market ready now.

Coretrack has designed and is in the process of completing development of the Core Level Recorder System (CLR with real-time telemetry) - a coring tool that will enable an explicit measurement of the acquisition of a core sample during a coring operation. The availability of real time data on the rig floor will ensure substantial cost savings to the exploration and production companies.

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MEASUREMENT WHILE CORING—MEASUREMENT OF CORE ACQUISITION IN REAL TIME

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ABSTRACT

Coring technology has remained relatively unchanged for decades. One of the primary technology gaps has always been the lack of real-time data at the surface on core recovery. Coretrack has developed the Core Level Recorder (CLR), a core recovery tracking tool that delivers accurate core-to-reservoir correlation. The CLR can be coupled to a mud pulser system to deliver surface readout on the core recovery process delivering accurate core-to-reservoir correlation in real time. The CLR is placed inside the inner core barrel and moves upwards as core is recovered into the barrel recording the amount of rock captured in a time versus distance format. The transmission of this data to surface provides the real-time information on whether or not core is being recovered and accurately records any gaps in the process allowing the core to be correlated to the formation with ±50 mm accuracy.

The CLR has been designed for use in both water and synthetic oil based drilling fluids of up to 125 °C and 10 kpsi with runs carried out in a variety of both on and offshore wells in Oman, Saudi Arabia and Australia. The CLR can be run in deviated holes and in all currently available core barrels. The most common size is for 4 inch core, however it is easily adapted for other barrel diameters.

Real-time data transmission enables the coring technician to accurately state when core is being recovered. This greatly increases the ability to state when core milling or core jams have occurred—a notification that removes unnecessary round trips and brings significant savings.

This paper will present case histories of runs made with the CLR.

KEYWORDS

Coring, real-time, reservoir, geology, drilling, telemetry, down hole, core milling, core jamming, cost saving, field life cycle, exploration, reserve estimation, industry survey, field trials, patent, drilling fluid, core expansion, trip out, labour shortage, technology, regulators.

INTRODUCTION

Coring is a critical component of the formation evaluation process during the appraisal and development phases of the field life cycle. It represents the only method of recovering large pieces of formation for detailed analysis to provide rock properties and descriptive data that cannot be determined from any other source. Data returned from cores enhances geological and petrophysical models, lithology identification, porosity and premeability characteristics, storage capacity and production potential.

Coring currently accounts for approximately US$130 M in service company revenues and uses technology that has remained relatively unchanged for a significant period of time. The overall cost to the industry (including rig cost) is estimated to be in excess of US$650 M[1,2].

CORING PERSONNEL

Success in today's coring process relies very heavily on the experience of the coring service technicians. Successfully detecting core jamming and subsequent milling of core relies on interpretation of qualitative changes such as the rate of penetration, rotary torque and pump pressure. The interpretation of these changes in and of itself often results in additional lost rig time due to the decision-making process on whether to trip out or continue coring.

The changes in penetration rate, torque and pump pressure are subtle and very subjective, introducing interpretation problems that are significantly magnified in any floating rig operation and more so on deep water wells where rig movement introduces another variable that can result in a halt in the rate of penetration (ROP) that is not noticed for a significant period of time. It is precisely these deep water fields that are increasingly being exploited.

CORING COST PRESSURES

Despite the flaws associated with the obvious qualitative nature of this process, it has been used with reasonable success for many decades; however, errors do occur resulting in unnecessary trips and lost core as a result of jamming and subsequent milling.

As core is normally a critical factor in accurately determining rock properties and appraising field potential, the

decision needs to be taken as to whether or not to plug back, sidetrack and repeat the coring process. If the decision is taken to repeat the process, the accumulated cost of the original coring job, along with the costs associated with sidetracking and repeating the operation, can run to millions of dollars.

A recent legal case against a major oil company in the United States over the level of accuracy of booked reserves has led regulators and investors to pressure for increased levels of coring to substantiate reserves estimates. Canada has moved toward all fields to be cored to support reserves estimates. As a result of these pressures there is the move towards increased levels of coring in many parts of the world.

Globally, rig spread costs range from US$50,000 to over US$1 M per day (Smith, 2007). This cost—coupled with the loss of experienced personnel from the industry and a resultant increase in poor operational decisions—has resulted in an overall increase in the cost of coring and introduced a strong driver to increase the sophistication of the coring process.

CORETRACK

Coretrack plans to offer two levels of data recovery. The Core Level Recorder (CLR) is a recorder unit that measures the movement of core into the core barrel, accurately identifying where any loss of core has occurred after the unit is recovered from the core barrel.

The Measurement While Coring technology (MWC) couples the CLR to a proporetary transmission system and a commercial mud pulse unit to deliver real-time data to the rig floor on the acquisition of core.

The CLR was commercialised in the second half of 2008 and the MWC technology is expected to be commercialised in the first half of 2009.

The MWC will largely remove the need for the analysis of qualitative data to pick up core jams and core milling. The technology will show to an accuracy of ±50 mm where the core loss or jams occur in real time. If there is no core acquisition and ROP is positive, then there is either a jam or core is not being acquired (i.e. unconsolidated rock) or milled away.

This technology offers the first tangible methodology for quality controlling the coring process. The current process relies exclusively on the experience of the coring engineers —there is no back up system. MWC offers the industry insurance against unknown jamming and unncessary trips.

SURVEY

Due to the qualitative nature of the changes in data for picking up jams and the number of coring practitioners spread across the globe, there is not a concise and publicly available document that summarises the relevant data. Coretrack has commissioned work to collate the data and some of that is presented here. Individuals employed by 25 companies in 52 locations were contacted with 35 respondents replying. The data presented in the report was obtained through a telephone questionaire survey, desktop research and from the author's contributing consultants' collective knowledge. Anecdotal information has been obtained through oil, gas and mining industry contacts. Results have been tabulated in Table 1.

USING THE TOOL

The CLR (Fig. 1) is a measuring and recording device that is placed inside the inner core barrel. During coring, the unit rests on the column of core as it is recovered into the barrel (Fig. 2) and records the amount of core captured. If the MWC system is in use, the data is transmitted up the inner core barrel by the proprietary Coretrack telemetry system to the top of the inner core barrel and around the swivel joint to the mud pulser where the data is then

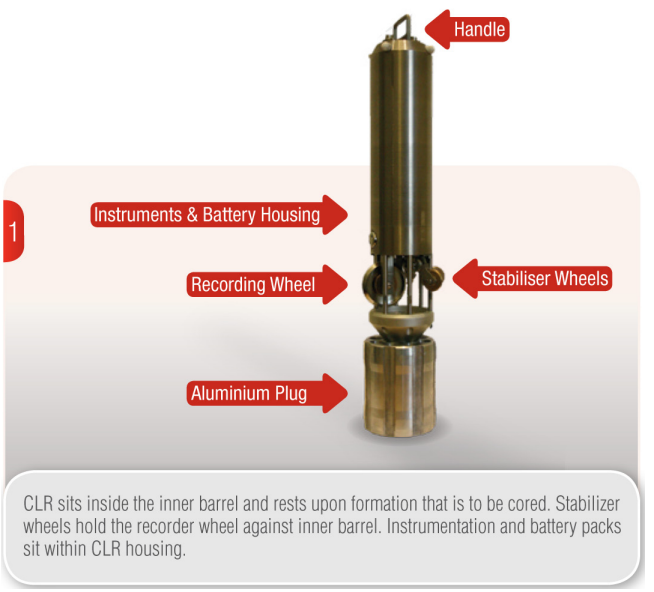

Figure 1. Core Level Recorder (CLR).

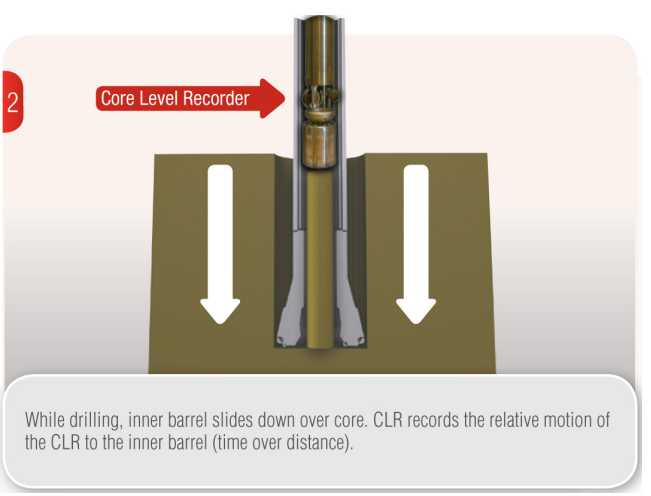

Figure 2. Core Level Recorder (CLR) inside inner core barrel and supported on top of core.

transmitted to surface (Fig. 3). The Coretrack patented ball drop mechanism replaces the conventional ball drop system because of the introduction of the mud pulser above the core barrel, which obstructs the normal path of the ball. An advantage of the Coretrack patented ball drop mechanism is that the ball drop from surface is avoided, thus saving additional rig time.

The CLR is loaded into the inner core barrel off the critical path so it does not add rig time. The mud pulser and other associated equipment are assembled at the same

Table 1. Summary of responses to industry survey.

Question	Highest	Lowest	Average Response
Predominant formations in which coring takes place	Sandstone	Basement	Sandstone (44%) Under-compacted (17%) Over-compacted (5.5%)
Formations encountering greatest loss while coring	Under-compacted sandstone	Shales	Sandstone/limestone including under-compacted (55%)
Average runs/coring job	20	1	2.4 (did not take into account the two highest of 18 and 20)
Average length (days) of coring job	14	1	3.4
Major factors contributing to core loss			Unconsolidated jams, jamming, change in formation (jamming)
Percentage of jobs experiencing milling	50%	1%	6–12% (6% assuming respondents that did not answer was zero)
Percentage of jobs experiencing jamming	100%	2%	27%
Percentage of jobs repeated	100%	Less than 5%	41.8%
Core loss of less than 33% constitutes failure			83%
Core loss experiencing less than 67% constitutes failure			17%
Tool loss	0%	10%	Less than 1%
How many coring jobs ongoing at any one time—on shore	100s per year (Canada)	3 per year	2.5 per month
How many coring jobs ongoing at any one time—off shore	5 per month	Less than 1 per month	1.6 per month
Percentage of jobs on shore			41%
Percentage of jobs off shore			59%

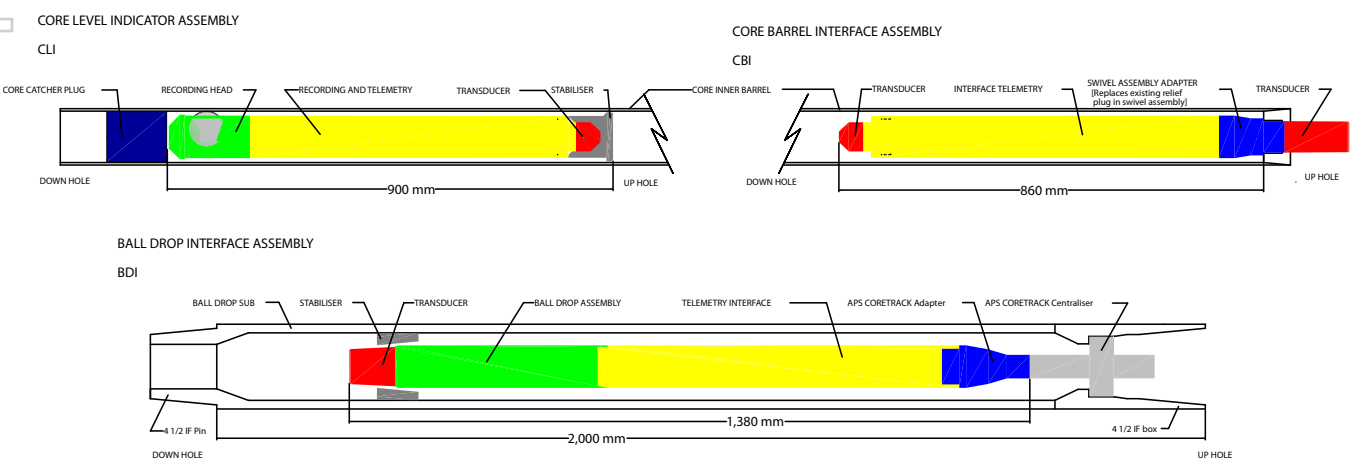

Figure 3. Core Level Recorder integrated with the MWC system.

time as the core barrel assembly is made up to the drill string with minimal impact on rig time.

OUTPUT

The recorded (or transmitted) data gives the history of the core column captured in a time versus distance format. Figure 4 presents a plot that was generated during a down hole test. Note that during trip in the CLR is forced up the core barrel by the drilling fluid. The CLR then settles down. The CLR stays at the bottom until coring begins.

The flat area of Figure 5 (at hour seven of core acquisition) is where a stand was added during coring.

It is interesting to note in Figure 4 that expansion of the core has been recorded while tripping out of the hole. This data is valuable to determine whether fractures in the sample may be the result of an overly rapid trip out speed. Tripping out speed is normally limited to allow time for entrained gases to exit the material without fracturing of the sample.

TEST RESULTS

The CLR has been designed for use in both water and synthetic oil based drilling fluids up to 125 ˚C and 10 kpsi with runs being carried out in a variety of both on and offshore wells in Oman, Saudi Arabia and Australia. The CLR can be run in deviated holes and in all currently available core barrels. The most common size is for 4 inch core, however it is easily adapted for other barrel diameters. Table 2 provides a summary of CLR runs at the time of writing.

VALUE PROPOSITION

Drilling

The most commonly cored formation is sandstone, with sandstones and limestones being the most common formation from which loss of core occurs. Typically, loss of core results from jamming or because the rock is unconsolidated. Coretrack's industry survey results show that core milling occurs in up to 12% of core operations and jamming in an average of 27% of coring activities. Of the jobs that are jammed or milled, the jobs are repeated 42% of the time. Clearly, loss of core is a common problem. As discussed, jamming can be difficult to identify, with the cost of tripping out unnecessarily when jamming has not occurred, balanced against the cost of a long diagnosis of a potential jam. The decision-making process associated with diagnosing a jam can take a considerable amount of time.

Real-time measurement of core recovery will deliver tangible benefits for the industry, reducing lost time associated with core jamming and core milling and introducing more certainty into the process. Early identification of problems will result in both cost savings and reduced time associated with remedial rig operations. Coretrack's industry survey found that respondents felt the real value offered by the Coretrack's technology lay in the improved accuracy of the coring operational decision-making process

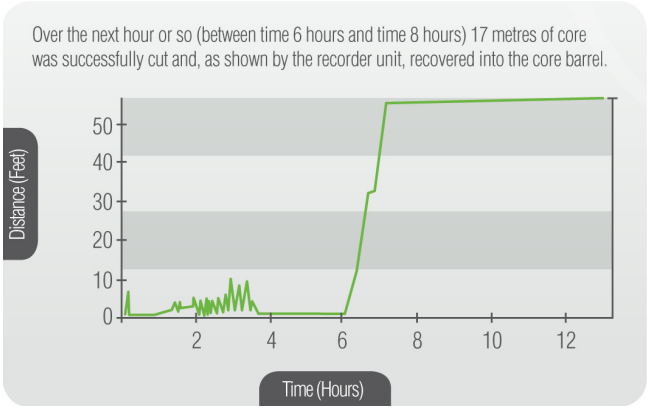

Figure 4. Full plot of trip in, coring and trip out.

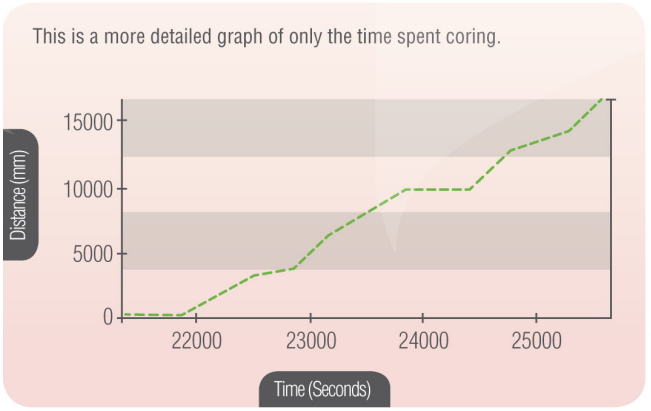

Figure 5. Enlarged plot of core acquisition.

and the potentially dramatic reduction in cost associated with remedial operations. The respondents also expressed a view that the real-time information would enhance core correlation to log data and increase the accuracy of estimates of field volumetrics and production potential, reducing risk for development of the field.

The overall cost of coring will be reduced through the use of Coretrack's MWC technology as a result of reductions in lost core and unnecessary trips for jamming and minimisation of remedial coring runs.

Geology

The recorded or transmitted data will provide geologists with accurate data on where core was captured—or conversely lost—with ±50 mm accuracy to the formation from which the core sample was retrieved.

The prime value of the data is that the uncertainty with the correlation between the acquired core and log data is minimised. Electric logging tools could be considered a competitor to the Coretrack technology, but electric logging is not carried out concurrently with coring operations.

The survey also supported the view that monitoring the expansion of the core during trip out would add value through greater understanding of rock properties and in-situ rock fractures.

Table 2. Summary of well parameters.

Well parameters	1 & 2	3	4	5	6, 7 & 8
Depth in/out	1,720–1,836 m	1,294 m	952–970 m	970–987 m	2,550–2,586 m
Core recovered	29 m	9 m	18 m	17 m	108 m
Max pressure					3,550 psi
Mud type (WBM/SBM/OBM)	WBM[i]	WBM[i]	WBM[i]	WBM[i]	SOBM[ii]
Mud weight	Water	Not known	10.88 kPa	10.88 kPa	1.19–1.24 SG
Lost circulation material	No				$CaCO_3$ 30–200μm
Max temperature	65°C	76 °C	70 °C	70 °C	106 °C
Rig type	Land	Land	Land	Land	Platform
Deviation	0°	0°	0°	0°	17° at core point, 40° max above
Type of inner core barrel used	Fibreglass	Al (Std)	Fibreglass	Fibreglass	Fibreglass
Issues	broken solder joint to internal battery pack	Thick fluid jammed tool at top of inner barrel	Ran out of memory during trip in due to larger than anticipated travel in barrel	None	Ran out of memory during trip in due to larger than anticipated travel in barrel
Remedial action	Encapsulate solder joints	Increase weight and allow passage of drilling fluid	Increase memory and allow for less resolution	Not required	Increase memory and change software to delay recording until after trip in complete

Notes: (i) WBM—water based mud. (ii) SOBM—synthetic oil based mud.

Business

Existing industry technologies offer some opportunities to increase the accuracy of core to formation correlation and as such, present a potential risk to the adoption of Coretrack's technology. Technologies that can be used to assist in core correlation and, in some cases, negate the need for coring include: mud logging, sidewall coring and formation image logging.

Problems with mud logging include mixing cuttings from various levels, contamination of the rock fragments by mud filtrate and the small size of the samples. Mud logging is therefore deficient in many ways, but most significantly in measuring the porosity of the formation.

Samples from the sidewall coring process are normally deformed, compacted and fractured as a result of the destructive (explosive) collection process and there is also some uncertainty in sample depth, particularly in deviated wells. Even with rotary sidewall coring, the size of the samples are often too small for some tests[3]. With sidewall coring in general, one sample may be required to represent many feet of reservoir and hence a full sample is more desirable[4].

The interpretation of electric logs, such as gamma ray, involves a number of assumptions and results in inferred formation parameters and uncertainties in field potential. This also involves a separate process of welling logging that is not done concurrently with drilling, which greatly increases the cost. The CLR plus telemetry is run concurrently with coring and hence saves a great deal of money.

As such, coring is the only evaluation process that provides real formation data that can be used to accurately correlate all other data collected during the drilling process.

CONCLUSION

The loss of experienced coring specialists and the inherent uncertainties associated with the interpretation of coring data demands the introduction of new technologies to optimise the coring process. Coretrack provides the technology to take the guess work out of managing the coring process and delivers the data to enable accurate core-to-reservoir correlation with minimal impact on rig time.

Increased pressure from regulators and investors for more accurate estimates of field volumetrics and productivity has increased the demand for accurate reservoir rock data and, as a result, core data. This increased need for core data drives the need for technology to decrease the risk and cost of coring activities.

Real-time measurement of core recovery will deliver tangible benefits for the industry, reducing lost time associated with core jamming and core milling. Early identification of problems will reduce remedial rig operations. Improved data will improve the decision-making process during coring operations, providing for reduced operational costs. Real-time information will enhance core correlation

to log data and increase the accuracy of estimates of field volumetrics and production potential, thus reducing risk for development of the field.

NOTES

1. Coretrack Limited Technical and Commercial Report, 2008. Oil Advisors: London House, Perth.

2. The world offshore oil and gas production and spend forecast 2007–2011, http://www.dw-1.com.

3. http://www.geomore.com/cores.htm.

4. http://www.corelab.com/rd/PetroleumServices/Routine/sidewall.aspx.

THE AUTHOR

Greg Wheatley has a PhD in mechanical engineering from the University of Western Australia. His PhD work in fatigue failure of rail in the Pilbara region of Australia was industry supported by a global mining company. After completing his PhD, he was awarded a postdoctoral fellowship position at the National Institute for Materials Science in Japan working on fatigue failure of welds. He then worked in product development and commissioning for five years on a new nondestructive testing product in the aviation industry. Greg returned to resources and spent years in project management and technical areas in the oil and gas and mining sectors. He now heads the technical department for Coretrack Ltd. He has published over 20 technical journal and conference articles.

APPEA