IATMI22-191

Lesson Learned Coring Job at "P" Field using Conventional Coring Full Closure System

Rio Irawan*[1], Teddy Sahat Yudianto Hutabarat[1], Kristanto Wibowo[1]
[1] PERTAMINA HULU ROKAN
* Email: rio.irawan@pertamina.com

To ensure high recovery of core from the first coring job, a conventional coring full closure system was used. A full closure coring tool is an ideal solution, not only for soft, sandy, unconsolidated formations, but for problematic applications such as gravely, fractured, or under-gauge core that conventional spring catchers cannot handle. Full closure coring tools ensure capture and a high recovery rate with hydraulically activated which minimizes mechanical parts and increases reliability for a broad range of applications.

"P" field itself has a gravely characteristic formation that gives challenges to hole cleaning, but the main target of coring is at "B" formation below gravel depths. B formation characteristic is shally-sand/ sandstone and already depleted showing from surrounding wells that give another challenge to loss circulation.

Prior to penetrating this sand formation, selected producers well within a radius of 200 m which produces from the corresponding layer of formation are shut in to overcome the loss circulation risk. Coring fluid also contained additional preventive LCM as a bridge agent across the depletion zone.

Another lesson learned is the coring BHA cannot be used as "reamer" prior the 2nd coring. Major concern was it may cause shear pin to prematurely sheared. Therefore, after directional BHA continue to the 2nd top coring depth, a hole opener was used to smoothen the wellbore and to ensure its hole cleaning. This practice proves successful to overcome the risk of shear pin prematurely sheared inside coring BHA at the top of coring depth.

The original plan coring job is to be done in 2 runs which target 30 ft in each run, but in the second run, after 14 ft of coring, there is no ROP, therefore the third run is required to finish the rest of 16 ft formation. The first run was successfully done with 99.3% recovery, the second run with 65.7% recovery but the third coring is only 13.7% recovery. During the coring job, there is no loss circulation occurs.

Keyword(s): coring, BHA, recovery

1 Introduction

1.1 *"P" Field Characteristic, Central Sumatra Basin – Indonesia*

"P" Field is located at Central Sumatra Basin Indonesia and has been developed since 1973. It has the characteristic of gravel formation from ~850 ft TVDSS - ~2200 ft TVDSS interbedded with shale formation. While pore pressure at reservoir depth is subnormal (below water pressure gradient) or depleted. The target of "P" field reservoir is named "B" formation.

1.2 Coring BHA

A full closure system coring tool was chosen because the coring target, primarily sandstone, which was excellent for soft, sandy, unconsolidated formations. The core head specifically is designed as Low Invasion Bits, constructed to deflect fluids away from the core ensuring it is preserved naturally, detail can be seen at Figure A1. Since the bottomhole temperature is under 200 degrees Fahrenheit, the coring BHA uses a fiber glass type inner barrel, which is simpler to split into smaller pieces for surface handling. But aside from that, the WOB limit for the fiber glass inner barrel is 28 klbs.

Conventional Coring Full Closure System (CCFCS) uses two catchers:

1. Gripping Sleeve that has a function to catch and hold soft formation when it collapses.
2. Heavy duty spring catcher that has a function as secondary catcher if the gripping sleeve cannot collapse properly due to hard formation.

The mechanism is started, when the core passing through heavy duty spring catcher, the catcher grip is in loose condition when core enters core barrel, but when the Coring BHA is lifted, the catcher grip will engage and hold the last core drilled inside coring BHA.

Conventional Coring Full Closure System uses 2 drop balls, 1-1/4" and 1-5/8" sizes which have function and procedures as following:

1. When core head reach top coring depth, drop 1-1/4" ball and apply pressure to the screw selection to divert coring fluid flow from inside BHA to Core Head nozzles
2. When coring operations has completed, the second ball 1-5/8" is dropped to push box hanger (above core barrel) subsequently break the shear screw
3. 8 Small balls around the box hanger acts as bearing to prevent sudden drop of core follows box hanger movement down, and the flow diverts to enter the shoe assembly through holes
4. During under pressure the sleeve is in compression mode and hold coring in place

Detail can be seen at Figure A3.

2 Case Study: Coring Job at "P" Field

2.1 Coring Objective & Strategy

Coring is a comprehensive method of collecting reservoir data in formation evaluation. It can provide hands-on laboratory testing and evaluation (core analysis), geological description (lithological and petrographic evaluations), geomechanical testing so that the current reservoir can be defined, integrates, and calibrates for future well logs, and verifies hydrocarbon reserves in place. Subsurface data must be collected during development process of "P" field block 3 in order to maximize production. One of the data is observing changes in reservoir properties following waterflood injection.

Drilling wise, coring job success ratio is not only high recovery of cores but also the quality and condition of cores at surface. A successful coring job depends on a number of essential factors, including the use of

proper coring fluid with low invasion characteristics, proper drilling parameters during coring, proper drawing out of the coring BHA schedule, and good surface management.
In addition, adding preventive LCM to the coring fluid, such as calcium carbonate, due to losses hazard in "B" formation, is to evaluate high-rate producer wells within 200 m that also produce from "B" formation and shut them in prior to coring "B" formation to minimize loss circulation potential.

2.2 Planning Phase

A successful coring job requires a good planning. Wellsite geologist, laboratory crews, coring crews, and petroleum engineering team are some of the parties that participate in planning and execution in addition to the drilling team. Coring job is not routine tasks, so prior to the start of the operation, everyone involved in the job must be aware of all in-place procedures and their roles. More information on the methods and tactics used before and during the execution of the coring job will be covered in this section.

2.2.1 Well Design

To increase success rate of coring job, coring depth is set at vertical section, either vertical well of S-type well. The detail of wellbore trajectory used for this case can be seen at Figure A4.

2.2.2 Top Coring Correlation & BHA Strategy

Determining top coring depth is not an easy job, many things could go wrong and resulting less formation target core to be recovered. Therefore, a good planning to determine top of coring point is critical.
There are some markers prior formation target that can be used as reference for actual correlation to formation prognosis, in this case there is "T10" formation that can be used for it. The uncertainty from "T10" formation to top of "B" formation is the shale thickness. Well site geologist, earth scientist and wireline logging job have the most critical role to make decision where the top of "B" formation is.
The strategy is as following:

1. Drill to "T10" formation depth (as per prognosis), pull out the BHA
2. Conduct Gamma-Ray Resistivity wireline Logging job
   a. Correlate prognosis and actual logging result to make more accurate prediction of top coring point
3. Continue drilling to coring point
   a. In this step, well site geologist will collect cutting sample (correlate with lag time for cutting appear on surface)
   b. Earth scientists determine top coring from cutting sample
4. Conduct coring job & repeat step 2 – 4 for the 2^{nd} coring job

While the strategy for drilling BHA is as shown at Figure A5.

2.2.3 Coring Fluid

Coring fluid used during coring is low invasion and non-damaging type water based mud with small fluid loss ($\leq$ 5 cc/30min), mud weight around 9.2 ppg (lowest fracture gradient at this section is 9.7 ppg). LCM that is mixed with coring fluid is $CaCO_3$ as bridging agent across depleted zone to mitigate loss circulation hazard. To achieve the most optimum composition of CaCO3 which gives the lowest spurt loss, the composition of CaCO3 fine : coarse is 5 ppb : 5 ppb. Another thing to consider is potassium iodide is also used as tracer to detect fluid invasion and displace old Mud w/ 9.2 ppg KCL 7% Hi-Vis, 120 smf, 25 bbls as push pill. For the specification of coring fluid can be seen in Table A2.

2.3 Execution Phase

Coring job was conducted using the BHA which mentioned previously. The drilling parameter was pre-determined and adjusted based on actual condition. The summary of the drilling parameter were shown in Table A3.

The first coring job, which took seven hours to complete with a 99.3% recovery rate on 30-foot cores, was executed according to the plan. After the coring BHA reached the top of the depth, coring fluid was pumped to prevent the invasion of old mud to the cores. The first ball, size 1-1/4" OD, was seated as per planned and 200 gpm was pumped by increasing pressure from 115 psi to 167 psi. The second ball, 1-5/8", was successfully seated when the top coring depth has reached, and the conventional coring full closure system (CCFCS) was initiated by pumping with 150 gpm. The pressure increased from 80 to 120 psi, indicating that the compression sleeve had collapsed. The flow rate and pressure were increased to 275 gpm and 500 psi, respectively, and this condition was maintained for 15 minutes to ensure the compression sleeve had entirely been compressed. A 10 klbs. overpull was seen, indicating that the core had indeed been extracted. The ROP ranges from 1.4 to 30 ft/hr with a normal drilling parameters.

The bottom depth of coring is 5425 ftMD, but during the second logging correlation to calculate the second top of coring, it gets stuck at 3600 ftMD. A second attempt at logging was not made because it was decided by earth scientists that the correlation for the second coring could be inferred from the first correlation and from cutting descriptions. To polish wellbore, a reamer with the same hole size (8-1/2") was run. If coring BHA is held up significantly above the depth of coring, there is a possibility of the shear pin being prematurely sheared inside. This technique is an adaptation of the BHA strategy depicted in Figure A.5 and has been proved to be successful in preventing coring BHA from becoming stuck inside the wellbore.

After the reamer pulled out of hole, the second coring BHA then is run. After the coring BHA reach the bottom of the hole, there are several depths above the coring depth and to save time the coring BHA was used to conduct wash and ream. After coring 14 ft, there was no significant progress made; the coring progress was only increased by 3 feet. To terminate the coring operation, the second ball was dropped, and the CCFCS was successfully turned on. Coring from the second work only achieved 65.7% (9.2 ft of 14 ft cores) inside the broken inner barrel when brought to the surface.

It was decided to execute an extra coring work to complete the remaining 16 feet of the core because the second coring job did not complete the 30-foot-long coring goal. Using new core barrel and same coring BHA as the first and the second coring jobs, the third coring is conducted, CCFCS was engaged as shown by 50 psi of surface differential pressure. However, there was no overpull when the coring BHA was pulled to look for a bottom-cut core. The drill string was suddenly dropped by 2 feet and the slack was reduced from 178 to 97 klbs during this effort. Visual investigation revealed that the inner barrel was shattered and had stabbed the outer barrel, leaving only 2.2 feet of the 16 feet intact.

From the 3 coring jobs done at “P” field, the results are shown at Table A4.

3 Lesson Learned & Conclusion

3.1 Technical Highlight

The following are some technical highlights from the coring activity at "P" field:

1. The first coring task produced a very acceptable coring recovery result (99.33%)
2. A full closure coring BHA restriction on unsmooth wellbore trajectory may cause shear pin to be sheared too soon and coring job cannot be done.
3. Additional round trip to conditioning the hole and not use coring BHA to do the job
4. The fiber glass inner barrel's maximum on WOB for coring is 28 klbs. WOB more than 28 klbs, as occurred during coring jobs #3 (80 klbs), can result in inner barrel breaking

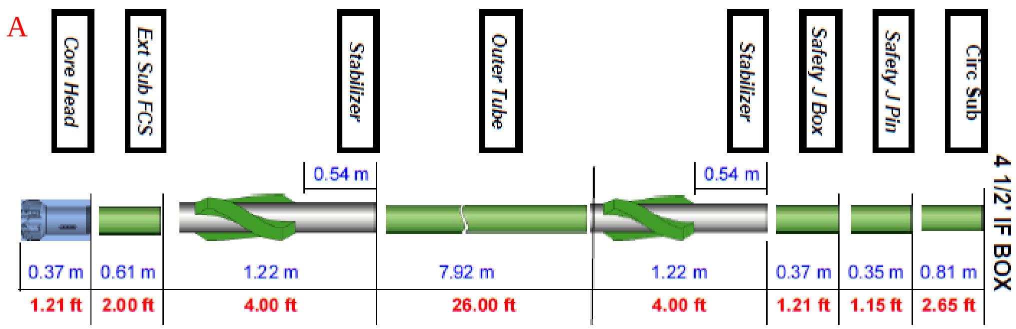
3.2 Non-Technical Highlight

The second and third coring jobs suffer from poor core recovery due to a mistake made in handling the coring BHA.

1. Not every driller had experience with coring activity
2. Coring considered as non-routine activity, so even the driller had done it before, does not guarantee that he able to do the same thing (better coring handling)
3. It is crucial to create do’s and don’ts procedures, and ensure that everyone involved in the coring job understand the procedures

Appendices A

Figure lists



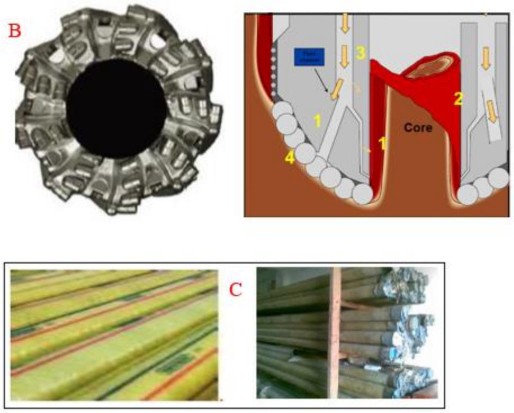


Figure A 1 (A) Full Closure System Coring BHA, (B) Core Head (Left) – Detail on low invasion mechanism (right), (C) Inner Barrel – Fiber Glass

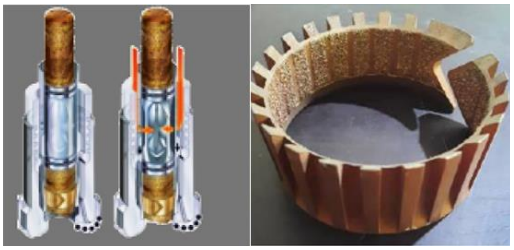


Figure A 2 (Left) Gripping Sleeve will collapse on soft formation, (right) secondary heavy duty spring catcher to hold hard formation

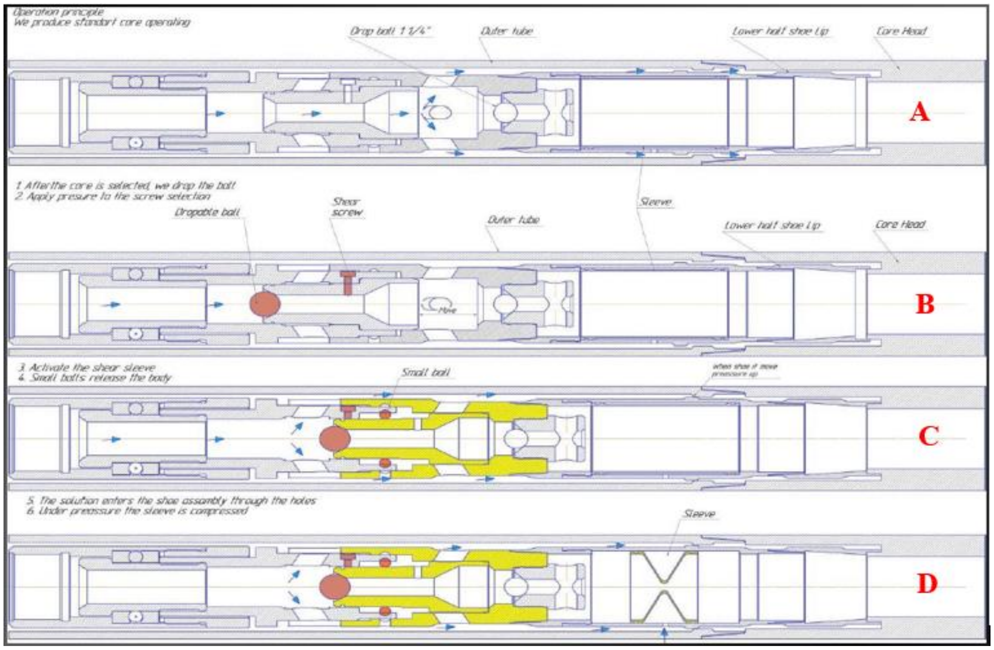


Figure A 3 Conventional Coring Full Closure System - Sleeve Collapsed Mechanism

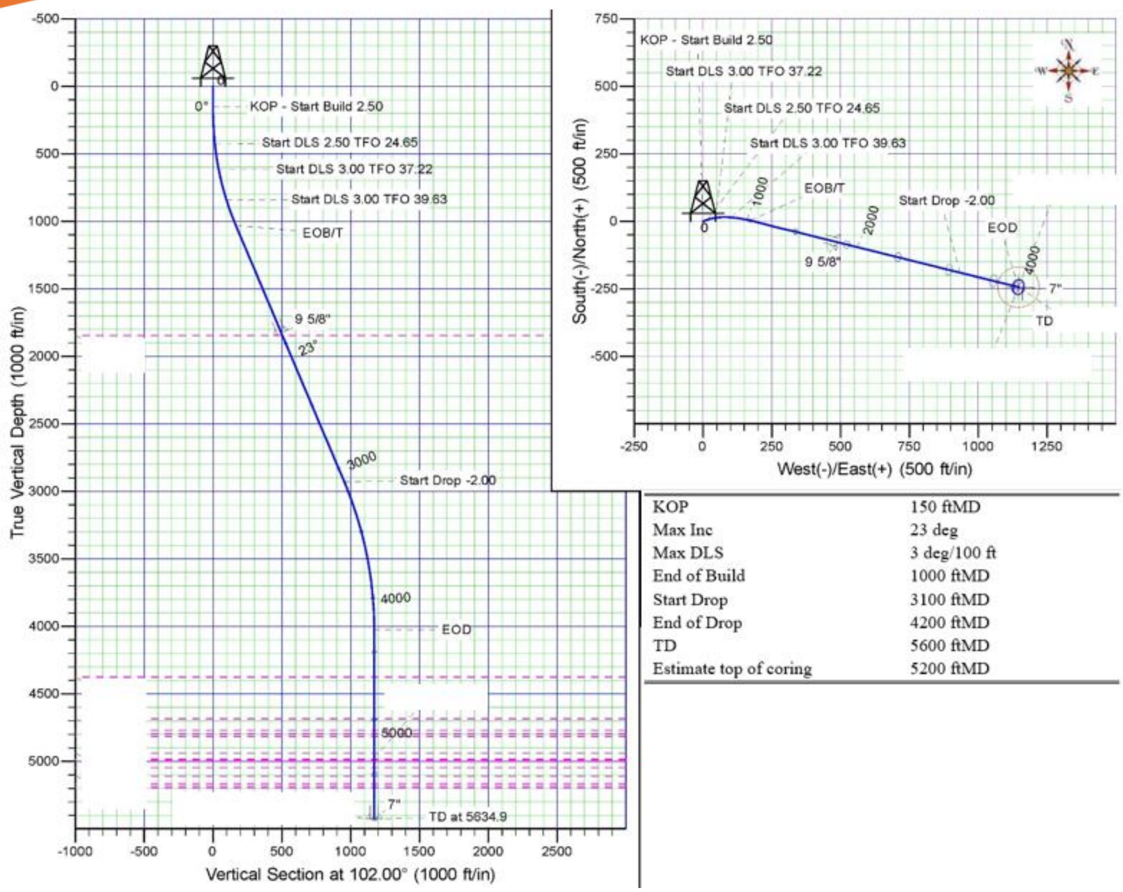


Figure A 4 Well design for coring job

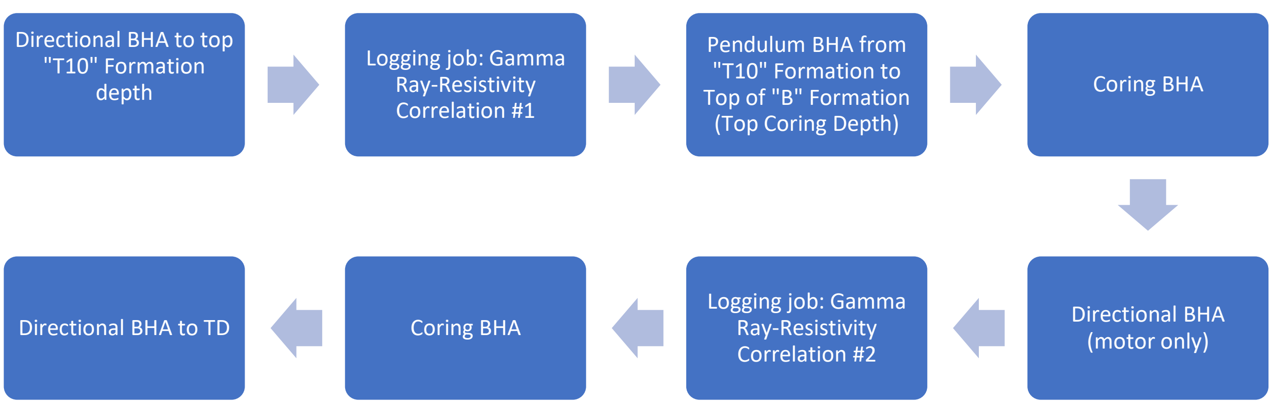


Figure A 5 BHA Strategy during Coring Job

Table Lists:

Table A 1 Core Barrel & Core Head Specification

Core Barrel	Core Head

Type/ Size/ Length	Conventional/ 6-3/4”, 42 ft	Type	PDC
Top connection	4-1/2” IF Box	Size	8-1/2” x 4”
Make Up Torque	25,800 ft.lbs	Thread	HDT
Pulling Capacity	506 klbs	Make Up Torque	25,800 ft.lbs
Max dogleg	10 deg/100ft	IADC	M333
OD stabilizer	8-15/32”	TFA	2 in2

Table A 2 Coring Fluid Properties

Mud Weight	9.2 – 9.3 ppg	Gel 10 sec/ 10 min	8 – 12 / 10 – 15	Sand Content	0.2 max
PV	< 20	PH	9.0 – 9.5	Cl-	~21,000
YP	20 – 25	Fluid Loss	5 max	Ca+	50 – 100
6 RPM Reading	10 – 12	Solid Content	6 max	K+	~24,000

Table A 3 Coring drilling parameters

1st Coring	Parameter	2nd Coring	Parameter	3rd Coring	Parameter
Flow Rate	200 gpm	Flow Rate	200 gpm	Flow Rate	200 gpm
Rotation	60 rpm	Rotation	60 rpm	Rotation	60 rpm
Torque	9200 – 10000 ft.lbs	Torque	9200 – 10000 ft.lbs	Torque	9200 – 11000 ft.lbs
WOB	2-7 klbs	WOB	4-15 klbs	WOB	6-10 klbs

Table A 4 Coring Job Results

Core No	Cut Core, ft	Length Recovered, ft	Core Recovery, %
1	30	29.8	99.3%
2	14	9.2	65.7%
3	16	2.2	13.7%
		Overall	68.7%

References

[1] Conventional Coring Full Closure System technical slides from PT Yahentama Persada

Acknowledgments

Special thanks for PT Pertamina Hulu Rokan, Mr. Andi Solihin, Mr. Candy Wijaya, Mr. Petrus Tri Wahyudi, Mr. Yudy Fitryansyah for all of the support given to us. We are also grateful for Mr. Dedy Setiawan & Mr. Anton Jaftoran from PT Yahentama Persada as the coring service provider, for all the hard work and source of information.