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OPTIMIZING RESOURCES

The Role of Drilling and Measurements While Drilling (MWD) Data In Reducing Formation Related Non-Productive Drilling Events

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Summary:

Formation and mechanical related drilling non-productive time (NPT) typically account for 10 to 14% of total drilling time. Geologic formation related NPT includes flat time associated with drilling events such as lost circulation, well control, wellbore instability issues, and stuck pipe. Mechanical related NPT is associated with equipment related problems such as BHA/MWD/directional or drillstring/bit failures.

By identifying the geological formation associated with these hazards, the operator is better able to prescribe drilling practice to mitigate these events, thereby reducing well costs. This information, however, is typically not readily available in drilling operations reporting systems.

By combining drilling data and Measurements While Drilling (MWD) and Logging While Drilling (LWD) data with detailed daily drilling operations reporting information, we are able to better identify formations most likely to be responsible for drilling problems so that this information may be incorporated into the well design. In addition, MWD/LWD data can contain information which is useful in understanding the nature and root cause of these problems.

Introduction:

Below historical oil and gas prices has sharpened our need to reducing well costs. This paper describes an approach to reducing well costs by focusing on formation related NPT events. Figure 1 below displays NPT events within the geologic framework model (depth domain).

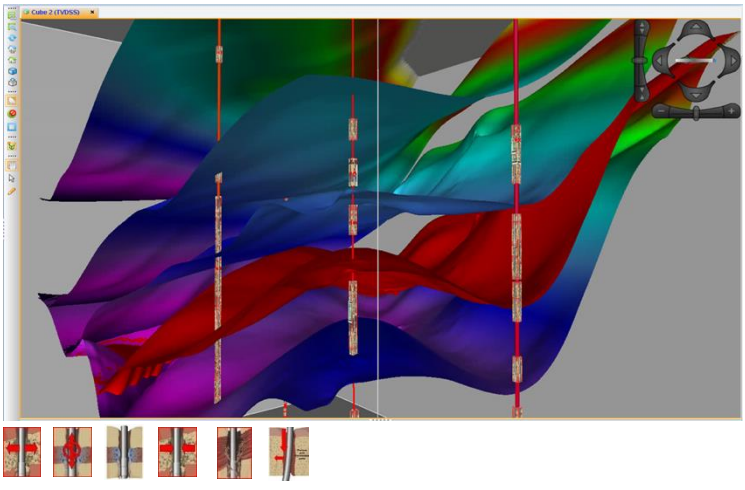


Figure 1: Drilling non-productive events mapped into the sub-surface framework mode

These events are attached to the wellbore at the hole depth at which the issue is thought to have occurred. Symbology associated with the events allows the viewer to readily indentify the nature of the non-productive event. Assigning hole depth to NPT based on drilling operational reports is problematic because these reports typically are referenced to hole depth as opposed to bit depth. As a result, it is often difficult to accurately assign hole depth to the problems encountered when the bit is off bottom, such as pack-off events while tripping. An improvement in this assignment may be found by linking real time data such as MWD/LWD at the data source level. While not perfect, this assignment more accurately describes the hole section associated with the root cause of an NPT event.

Method

Offset well locations are selected on the basis of proximity, wellbore geometry and target interval. Additionally, offsets may be screened by date because the technology evolves rapidly over time. Structured Query Language (SQL) queries provide drilling operational reporting against the database.

Key information extracted from the daily operations reporting data include the following:

- NPT Type
- Operation Depth
- Operation Date
- Drilling Activity
- Drilling Phase
- Operation Comment
- Drilling Operation Hours

Key information extracted from the drilling data of significant interest includes:

- Bit Depth
- Torque
- RPM
- Standpipe Pressure
- WOB, Hookloads
- Mud Weight, Mud Volumes
- Cuttings returns

Key information extracted from the MWD/LWD data of significant interest includes:

- Resistivity and other formation characteristics
- Gamma Ray
- Equivalent Circulating Density (ECD)

In addition, multi-arm caliper logs are useful in the identification of washout zones, as well as to identify the impact of geomechanical stress on borehole geometry. The integration of MWD/LWD data with drilling operations data enables the production of the chart displayed in Figure 2 below.

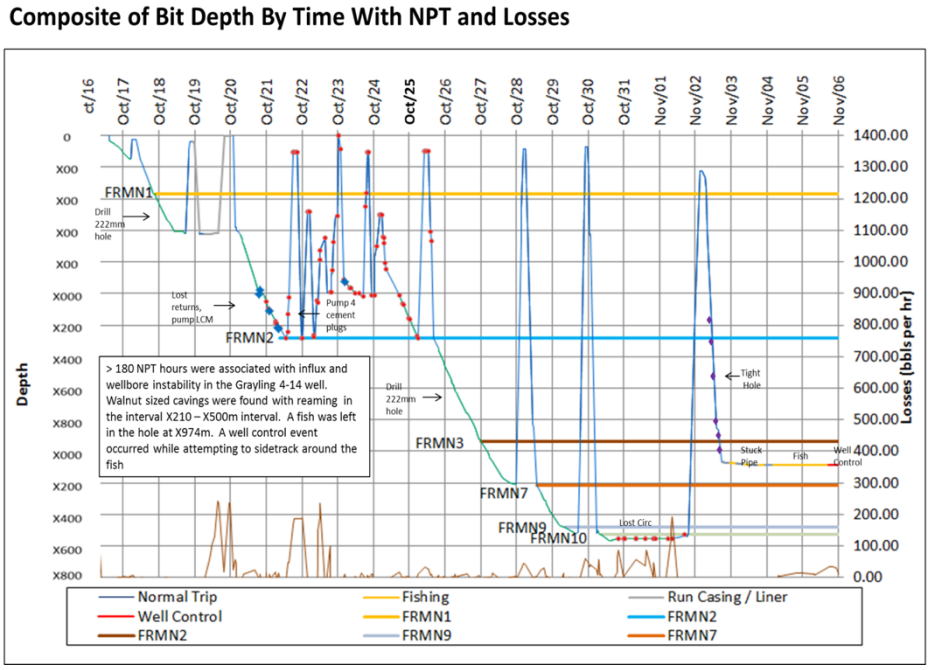
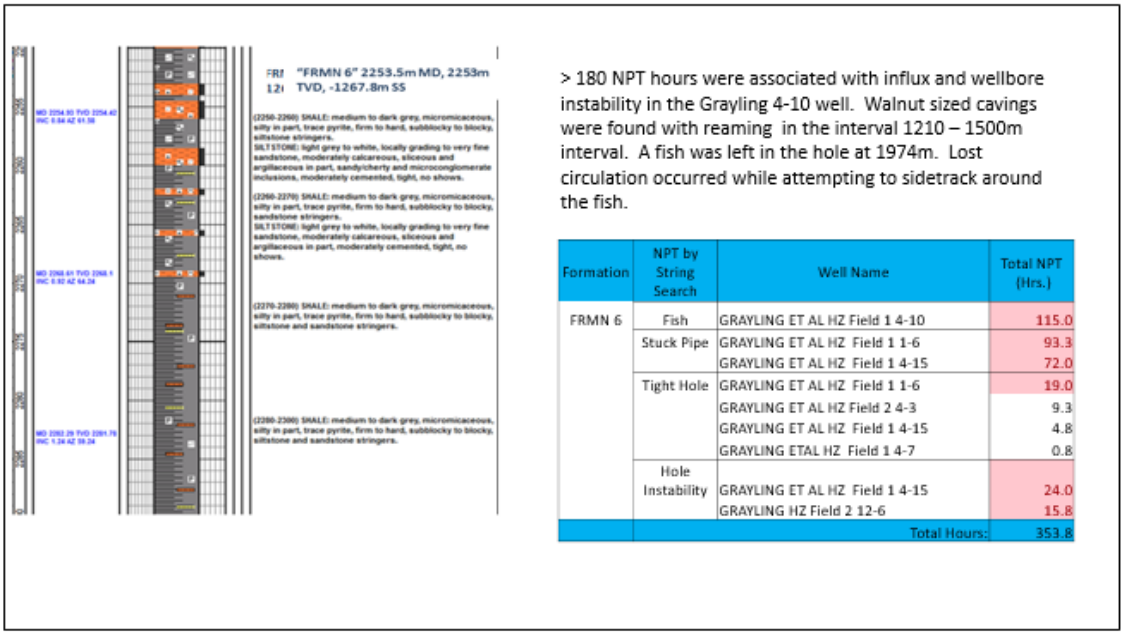


Figure 2: Composite of Bit Depth By Time With NPT and Losses
(can be modified as per NPT type)

By linking the geologic formation and NPT event, we are able to create a profile of potential hole problems associated with specific formations. An example is displayed in Figure 3 below:



Formation	NPT by String Search	Well Name	Total NPT (Hrs.)
FRMN 6	Fish	GRAYLING ET AL HZ Field 1 4-10	115.0
	Stuck Pipe	GRAYLING ET AL HZ Field 1 1-6	93.3
		GRAYLING ET AL HZ Field 1 4-15	72.0
	Tight Hole	GRAYLING ET AL HZ Field 1 1-6	19.0
		GRAYLING ET AL HZ Field 2 4-3	9.3
		GRAYLING ET AL HZ Field 1 4-15	4.8
		GRAYLING ETAL HZ Field 1 4-7	0.8
	Hole Instability	GRAYLING ET AL HZ Field 1 4-15	24.0
		GRAYLING HZ Field 2 12-6	15.8
		Total Hours:	353.8

Figure 3: NPT associated with a particular formation

Once potential drilling problems have been assigned to the geologic formations identified in the well prognosis, a Hazards Forecast describing practices which will help to prevent/mitigate events may be prepared along with a description of the protocol to be used to communicate these to both office and rig personnel (Figure 4).

9 7/8" Intermediate Hole Casing: X50.0 – X615.0m MD.

Risk	Probability	Impact	Interval	Discussion	Prevention	Preventative & Mitigation
250mm Casing Point pick & FIT/LOT	Low	Moderate	X15m MD	Critical casing point pick - Land casing at base of FRMN 7. Note that FRMN 7 is thin (1.5m) and the underlying FRMN 8 is dolomitic, with a risk of mud losses. Note: an alternative landing point is the top of the FRMN 9. GRAYLING 02 HZ FIELD1 7-8: Drill ahead 251mm in FRMN5, FRMN6 Fm f, mud loss's started @ 10m3/hr., stop pumps, monitor well, top fill with fill, start pump at 1m3/min and mix lcm pills and pump.		• Ensure we have a good correlation to pick the casing point in the correct formation • CBU to check formation as required
Mud Losses / Loss Circulation	Moderate	High	X50 - X615m MD (FRMN2, FRMN1, FRMN3, FRMN4)	Seepage and partial mud losses & and complete loss returns into the FRMN 3, FRMN 5, and FRMN6 formations. GRAYLING 02 HZ FIELD1 7-8: Drill ahead 251mm in FRMN5, FRMN6. Mud loss's started at 10m3/hr., stop pumps, monitor well, top fill with fill, start pump at 1m3/min and mix lcm pills and pump Total NPT=44.25Hrs	• Monitor active system, trip tank volume and flow sensor for indication of losses and/or reduced returns • Complete surge/swab modeling to determine optimal trip speeds • Monitor ECD/ESD if available • Perform ECD modelling	• Monitor active system with alarms set; good communications for mud transfers • Pump LCM pills • Pre-treat mud with LCM / bridging agent program • Set cement plug and drill out (if necessary) • Avoid ballooning & swabbing; Stage up pumps & RPM in hi-risk situations to avoid surging • Optimize flow rates for losses and hole cleaning • Follow MW/ECD operating window and weight-up schedule • Establish ECD maximum limits based on last FIT and/or previous mud losses & monitor closely
Well Control	Moderate	High	X200 - X615m MD (FRMN3, FRMN5)	High gas from open fractures, gas, or water kicks. High gas from open fractures requires specific mud weight to avoid ballooning. 1. GRAYLING HZ FIELD1 5-6:. Well kicked. No pit gain, no flow increase, stayed in solution until kick was very close to surface. Then 4 m3 volume increase, 2 m3 was lost to rig floor, derrick and buildings. Well shut in. Evaluate kick. Total NPT=24.8Hrs 2. GRAYLING ET AL HZ FIELD2 6-7: (Base of FRMN 7.) Jarring and working pipe to try to free the fishing BHA. Drill pipe pressure increased during jarring process. Bled off several times and determined there was gas inside the drill string. Bled down until stable enough to install stabbing valve.	• Monitor RT pore pressure via pressure indicators • Fingerprint connection flow back volumes • Monitor background, drilling, connection and trip gas • Monitor trip volumes vs. actual • Monitor Flow Out and SPP • Monitor ECD/ESD within MW Window • Track kick tolerance as MW increases	• Monitor gas via mud loggers • Monitor active mud system, flow, SPP • Follow MW/ECD operating window & weight-up schedule • Weight up slowly, to avoid start of ballooning - loss & gain cycles. • Flow check as necessary • Avoid swabbing during trips; use trip records • Circulate out, increase MW as necessary • Use Fingerprinting (mud flow back) at connections
Wellbore Instability - Tight Hole	High	High	X250 - X400m MD (FRMN2,FRMN3, FRMN5,FRMN4)	Tight hole from formation issues including wellbore instability, ledges, etc.; related to overpulls, high & erratic Torque; can lead to backreaming/reaming, pack-offs and stuck pipe Most tight hole relates to reaming, back reaming (pack-offs and stuck pipe) and/or incorrect mud weights which can lead to ballooning. 1. GRAYLING 02 HZ FIELD1 7-8: Wiper trip. Flo-chk'd, pumped pill, tripped out - pulled tight Pumped out Circ. sample, rubble, fines. Con't trip out. w/o problem. Flo-chk'd. Cleaned up floor. Total NPT=11.75 Hrs. 2. GRAYLING HZ FIELD3 9-10:. Trip in hole w/ flo chks & fill pipe Wash and clean , 6m fill. Circ and work pipe, condition mud, raise mud wt to 1320kg/m3, vis w/Bentone 2 circulations. POOH 10 stands, flow check, pump pill, pull 1 stand dry, unable to pull ftite, break circulation & wash OOH . trip out. Total NPT=56.0 Hrs 3. GRAYLING HZ FIELD3 3-16:. Daily Operations- Ream in hole. Hole bridged off . Unable to ream. Back ream out of the hole, flowcheck. Total NPT= 735Hrs	• Monitor torque and drag vs theoretical while drilling • Monitor for pump pressure spikes for signs of packing off • Track Hookloads on trips • Maintain tight spot log	• Ream and/or backream at connections & while tripping as required but use Guidelines • Follow MW/ECD operating window & weight-up schedule • Monitor actual T&D vs theoretical; monitor tight spots and keep records on all trips • Optimize BHA stabilization • Avoid shallow DLS's • Circulate hole clean and wiper trip as required • Monitor cuttings loads/cavings (analysis) for signs of borehole instability

Figure 4: An example of a Hazard Forecast describing potention non-productive time by geologic formation and NPT event type

This approach provides a balance of NPT root cause and understanding together with recommendations for incident prevention/mitigation. This information may be combined with combined with easy to communicate graphics which are a valuable adjunct to NPT studies,

Conclusion

The association of drilling non-productive events to geologic formation can help to reduce well cost by enabling the drilling engineer to create plans to prevent and mitigate issues before they occur. Key to this discovery is the calibration of hole depth to formation. By integrating drilling and MWD/LWD data with drilling operational reports, we can improve our ability to reduce well costs associated with formation related non-productive drilling events, with appropriate prevention/mitigtion measures.