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.
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:

> 180 NPT hours were associated with influx and wellbore instability in the Grayling 4-10 well. Walnut sized cavings were found with reaming in the interval 1250 – 1500m interval. A fish was lost in the hole at 1974m. Lost circulation occurred while attempting to sidetrack around the fish.

<table>
<thead>
<tr>
<th>Formation</th>
<th>NPT by String</th>
<th>Well Name</th>
<th>Total NPT (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRMN 6</td>
<td>Fish</td>
<td>Grayling ET AL HZ Field 1-4-10</td>
<td>113.0</td>
</tr>
<tr>
<td></td>
<td>Stuck Pipe</td>
<td>Grayling ET AL HZ Field 1-4-45</td>
<td>93.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grayling ET AL HZ Field 1-4-45</td>
<td>72.0</td>
</tr>
<tr>
<td></td>
<td>Tight Hole</td>
<td>Grayling ET AL HZ Field 1-1-6</td>
<td>19.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grayling ET AL HZ Field 2-1-4</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grayling ET AL HZ Field 1-4-45</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grayling ET AL HZ Field 1-6-7</td>
<td>0.8</td>
</tr>
<tr>
<td>Hole Instability</td>
<td>Grayling ET AL HZ Field 1-4-45</td>
<td>24.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grayling ET AL HZ Field 2-1-6</td>
<td>11.6</td>
</tr>
<tr>
<td>Total Hours</td>
<td></td>
<td></td>
<td>251.8</td>
</tr>
</tbody>
</table>

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).

![Figure 4: An example of a Hazard Forecast describing potential non-productive time by geologic formation and NPT event type](image)

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/mitigation measures.