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Successful Execution of a Dynamic Driller's Roadmap Using an Automated Formation Top Detection Algorithm

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Abstract

Efficient drilling through heterogenous geology requires careful matching of drilling parameters to the rock being drilled. Failure to do so can lead to increased bit damage or poor drilling performance. The "driller's roadmap" is a list of such parameters to be changed at various depths where formation tops are expected to be crossed. Successful execution of these roadmaps relies on having a detailed geological prognosis of where specific formations will be encountered. When drilling the first well on a pad, the precise depths of geological boundaries may be unknown preventing successful roadmap execution. By providing a feedback loop between a driller's roadmap and an automated formation top detection algorithm, it is possible to identify and proactively respond to geology even when drilling in these uncertain conditions.

A roadmap was created with target drilling parameters for each formation that would be encountered when drilling. Critical formations were identified where there was a high degree of interfacial severity, suggesting a high potential for bit damage if cutter overloading occurs. To mitigate this, a transition to controlled depth-of-cut drilling would be made prior to formation entry. Gamma markers were identified for these formations, along with predictive gamma markers shallower than the transition zones. During drilling, an automated formation top detection algorithm was run on logging-while-drilling data providing a real-time alert when the predictive markers were detected. Remaining roadmap depths were updated based on whether these markers were shallower or deeper than the roadmap expectation. Gamma logs and drilling mechanics were monitored to confirm the depth where transition zones were encountered. This was repeated across the pad to confirm process reliability.

Two formation tops were identified that were expected to come in 450 and 170 feet shallower than the transition zone where the switch to depth-of-cut drilling would occur. When drilling the first well on the pad the automated formation top detection algorithm identified these tops as arriving nearly 100 feet shallower than anticipated by the pre-drill geology program. The roadmap was updated and the switch to depth-of-cut drilling was performed 100 feet earlier than originally planned. Post-well analysis showed the transition zone came in 95 feet shallower than expected, in line with the modified driller's roadmap, suggesting the modifications avoided unnecessary bit damage. Subsequent wells on the pad showed strong repeatability in formation top arrivals, and the updated roadmap was used without major modification.

The combination of driller's roadmaps and automated formation top detection is a key step toward efficient drilling/geology integration with an eye toward optimized drilling automation. This study shows this integration can lead to positive drilling outcomes even in areas with high levels of uncertainty in the location of formation boundaries.

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