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Overcoming Weight Transfer Challenges in Complex, Shallow, Extended Reach Wells on Alaska's North Slope

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Abstract

The complex wells currently being constructed to develop the West Sak Field on the North Slope of Alaska (Figure 1) are approaching the limits of extended reach drilling technology (Figure 2). Due to the shallow vertical depth and long horizontal departure of these wells, the ability to effectively transfer weight while drilling and running tubulars can be very challenging. This paper discusses the reasons those challenges exist, and the tools, techniques and learnings employed over the past seven years to successfully solve weight transfer challenges in this remote, environmentally sensitive area, including steerable motor assemblies, rotary steerable drilling assemblies, collaborative planning, on site drilling engineers, torque and drag reduction devices, fluid additives, vibrating down hole tools, and liner running with multiple trips. These learnings enabled the recent drilling and completion of a West Sak well with a total measured depth of 19,750 feet at a vertical depth of 3,055 feet. This well, with a horizontal departure of 18,472 feet and two laterals with lengths in excess of 7,500 feet, has a departure to depth ratio in excess of six.

Background

The West Sak field is within the Kuparuk River Unit on the North Slope of Alaska (Figure 1). The West Sak heavy oil sands contain highly viscous oil due to the low gravity of the crude (10 to 22 degrees API) and the low reservoir temperatures (caused by both the extreme northern latitude and the shallow (3,000 to 4,000 vertical feet) burial depth below 1,800 feet of permafrost in the overburden.) The West Sak reservoir has three primary sandstone targets: the “A2”, the “B” and the “D” intervals. The West Sak sands are “very-fine” to “fine” grained, single and amalgamated sandstone/siltstone beds. Geologic challenges while drilling include numerous fault crossings along the wellbore (Figure 3) as well as random encounters with calcite-cemented spheroids, also known as concretions (Figure 4). The concretions are much harder than the reservoir sand, having compressive strength of 25,000 pounds per square inch (psi) versus 500 psi for the reservoir sand. These concretions drill much more slowly than the adjacent sand which accelerates wear on the bit, the bottom hole assembly, and the drill string. This difference in hardness can also cause the drill bit to deflect off of the concretions resulting in unwanted severe doglegs. Such doglegs make it difficult to maintain directional control, increase torque and drag, and can cause down hole tool damage.

Early West Sak development consisted of stimulated vertical wells on a 40-acre water flood pattern with typical production rates of 150-250 barrels of oil per day. Because the North Slope is a remote and fragile arctic environment operators are motivated to develop progressively larger reservoir areas with increasingly smaller surface footprints (Figure 5). With the evolution in horizontal and multi-lateral drilling technology, the development plan has progressed from the early vertical wells to the current extended reach multi-lateral injectors and producers with horizontal and undulating slotted liner completions (Targac, et al, 2005). While this progression in the development plan has reduced the overall per barrel development cost, as well as the impact on the natural environment, it has presented challenges in drilling and completing the wells. To date 59 horizontal wells have been completed in the West Sak field, and the wells have evolved to longer and more difficult designs. One way in which the difficulty of these wells can be compared with one another is the Directional Difficulty Index (DDI), a calculation that takes into account the major contributing factors that affect the directional difficulty of a well (Oag, A. et al, 2000). Calculated thusly, DDI = Log [MD x Horizontal Departure x Tortuosity / TVD], the West Sak horizontal wells have had DDI values that have ranged from 6.35 in the early days to 7.66 on recent wells, more than a ten fold increase in difficulty (Table 1). Similarly the early wells, with departures of less than 5,000 feet and departure to