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Oil-Based Foam and Proper Underbalanced-Drilling Practices Improve Drilling Efficiency in a Deep Gulf Coast Well

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Abstract

A recyclable oil-based foam drilling fluid (OBFDF) system has been developed to expand the benefits of controlled pressure drilling with foam onto water sensitive formations. This paper describes chemical development and presents drilling results for a Gulf Coast well drilled with the oil-based foam system. Not only did results confirm the ability of the foam system to control fluid loss and preserve formation permeability, but also, show the advantages of drilling with foam. Furthermore, a bit trip was saved drilling the reservoir in a single bit run, with a high rate of penetration and reduced gas inflow while drilling. The OBFDF is versatile, stable at high temperature (up to 450°F), compatible with H_2S scavengers and reusable. Foam properties were successfully adjusted in presence of gas and condensate inflow. Still, the flexibility of foaming, defoaming and refoaming allowed surface separation and fluids reuse. Therefore, recycling liquid make up hydrocarbon reduced fluids and chemical usage with the associated cost reduction. Onsite modeling showed the controlled pressure contractor modeling software used for water-based foams can be adjusted to properly predict drilling parameters with oil-based foams.

Introduction

Mist and foam are the primary fluids to controlled pressure drilling formations with less than 4.0 ppge pore pressure. The drivers to drill with mist or foam include controlling fluid loss and differential sticking, increasing rate of penetration and minimization of formation damage. In these systems 55 – 99.9% v/v is gas and the rest is liquid. Liquids travel as droplets in mist drilling and as part of the bubble structure in foam drilling. The liquid phase is called make up or base fluid and is usually diesel, fresh water or inhibited water. The gas phase can be air, cryogenic nitrogen, membrane nitrogen, natural gas or exhaust gas. Foam is often preferred over mist because it offers increased ability to transport cuttings and to control bottomhole pressure. Foam also offers natural fluid loss control properties and helps minimize inflows due to increased viscosity. Reducing inflows minimizes surface handling cost, flaring cost and environmental impact. (Nas, 2006)

Currently there are several water-based foams in the market that control lost circulation and differential sticking, yet formation damage is still prevalent in water sensitive formations. To this end, the oil-based foam system was developed to extend the full spectrum of foam drilling benefits to water sensitive reservoirs. One of those water sensitive reservoirs is the retrograde condensate Smackover carbonate and Norphlet Sandstone in the Gulf Coast of the United States.

Historically, the Smackover and Norphlet have shown a 3-4 fold increased productivity in underbalanced wells drilled with diesel mist compared to overbalanced wells (Cade, 2003). The improved productivity is a great driver for underbalanced drilling but there are also several drilling challenges (Labat, 2000) viz:

- Wells are generally sour with H_2S concentrations around 100 – 700 ppm
- Low reservoir pressure. 1700 – 2300 psi at 18,000 ft or 1.8 – 2.5 ppge,
- Previous underbalanced wells showed rates of penetration (ROP) as low as 4 ft/hr and fast bit wear,
- High bottomhole temperature (BHT), ~ 350 °F,
- Up to 23 MMscfd of natural gas with 888 bbl/day condensate inflows while drilling,
- High total fluid cost because safety and operational concerns prevented from re-using base fluid (diesel) in sour environment. All liquids returns have been sent to the field's processing plant for treatment.