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An Investigation of Heavy Foam Properties for Deepwater Drilling

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Abstract

A unique problem of drilling oil and gas wells in deepwater is the narrow window between the formation pore pressure and fracture pressure. The current drilling practice with constant-gradient of drilling fluid requires excessive casing programs and larger, more expensive rigs to drill the formations. Although different techniques, such as dual-gradient drilling, have been used to ease the problem, they are limited to certain geological conditions. This study investigated the possibility of using heavy foam as the drilling fluid to solve the problem.

The heavy-foams studied include brine-base foams and barite-water-base foams. We found that the brine-base foams have lower foam stability, density, and quality index. But they have better flow properties. The barite-water-base foams have higher foam stability, density, and quality index. But their flow properties are not as good as the brine-base foams. We conclude that heavy foams can be made to have properties suitable for drilling deepwater wells to reduce casing programs. Use of the heavy foams will create larger boreholes for oil/gas production with much lower cost of well construction. Tremendous savings in the deepwater development are expected with this new technology.

Introduction

Since the geological evolution in the deepwater is thought to be similar to that in the continental shelf, huge hydrocarbon reservoirs are expected in situ. However prospecting for oil and gas has considerable risks and expenses. One of the major problems encountered is the narrow window between the pore pressure and fracture pressure gradients which occurs with increasing water depth. Typically, in deepwater environments, an increase in depth is accompanied by an increase in under-compaction of sediments, which causes a rise in pore pressures with decreases in both the vertical and horizontal stress gradients, so resulting in a closure of the pore pressure – fracture gradient window. This margin can be so close that a slight decrease in borehole pressure can lead to fluid influx, whilst a slight increase in borehole pressure can result in a loss of circulation (Sangesland, 2006). An excessive number of casings, i.e. 4 – 6 or even more casing strings, may be needed to reach the desired depths, resulting in grossly insufficient borehole sizes making the wells economically impractical.

The use of heavy foams as a drilling fluid is investigated to suggest a methodology for drilling in deepwater that minimizes the well control challenges and the limitations that are currently experienced in deepwater operations that allow for drilling longer hole-sections not considered possible with conventional drilling fluids. The purpose of using heavy foams as the drilling fluid would be to control any rapid increase in pressure gradient which could fracture shallower formations especially as experienced in the shallower formations in deepwater. The heavy foam would in essence operate on a similar principle to the dual gradient managed pressure drilling concept, with the higher foam density at the point of drilling and the lower densities further up the wellbore. The dual gradient method involves lightening of the drilling fluid by diversion of the returning fluid to the surface via a separate riser rather than the casing annulus. This diversion seperates the heavy mud above the sea bed from the wellbore, blocking it from exerting its influence on the exposed formation in the well. The hydrostatic head below the mudline is therefore made equivalent to its expected value with the rig at the ocean floor while maintaining sufficiently high drilling fluid density to contain formation pressures. The heavy foam profile would be similar to that of the dual gradient fluid except that it maintains a varying gradient and so drilling can be carried out in a tight operating window between the fracture pressure and the pore pressure to deeper depths before the need to set casing.

The main objective of this study is to investigate the possibility of generating heavy foams useful for deepwater drilling. Heavy brine and barite were used for weighting up the drilling fluid in this study. Several foaming agents and several other chemicals were used to form foams in brine with nitrogen gas.