



**SPE 116139**

## **Wellbore Stability Performance of Water Base Mud Additives**

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This paper was prepared for presentation at the 2008 SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 21–24 September 2008.

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### **Abstract**

A critical property for many water-base muds is the ability to prevent near-wellbore pore pressure increase in shales. By slowing or preventing this pressure rise, a true overbalance pressure is maintained, which promotes wellbore stability. Using a device that simulates downhole rock stress and overbalance fluid pressure conditions, and using preserved shale samples, we tested four different muds containing different additives. Direct measurements of shale pore pressure vs. time were obtained, representing the pore pressure inside the wall of the wellbore. All muds slowed the loss of overbalance pressure compared to a base-case brine fluid, but two muds were very effective at slowing and/or preventing the loss of overbalance. One active mechanism appears to be an increase in the osmotic membrane efficiency, but permeability measurements conducted during these same tests show that physical plugging of the pore space is also an important mechanism for these two fluids. Measurements of fluid-induced swelling were also conducted in this same set of tests, and all four muds resulted in less swelling than the base-case brine. The most effective fluid was repeat-tested using a completely different shale, and it again was found to be very effective at preventing near-wellbore pore pressure increase.

### **Introduction**

One of the main shale instability mechanisms that occurs with water-based drilling fluids is that the wellbore pressure penetrates into the shale pore space. This raises the near-wellbore pore pressure and reduces the true overbalance. This reduction of true overbalance, which acts like a support pressure for the hole, can result in shale failure and wellbore instability. The pressure penetration cannot be prevented with standard filtration additives, because shale pores are extremely small (~0.01 micron) and shale permeability is extremely low (typically ~0.01 microdarcy or less); therefore a filter cake does not develop on shales.

With oil-based muds, pressure penetration into the shale pore space generally does not occur. This is because of the following:

- There is a high capillary entry pressure for the non-aqueous fluid phase.
- A good osmotic membrane exists (as long as the emulsion is stable), enabling the salt content of the water-phase to prevent osmotic transfer of water into the shale.

Water-based muds in the past have rarely been effective at building an osmotic membrane or at preventing hydraulic flow into the shale.

The industry has attempted in recent years to develop water-based muds that perform like oil-based muds, especially with regard to shale stability. To test the effectiveness of different brines, additives, and muds at preventing near-wellbore pore pressure increase, various laboratory test methods have been used. The test is usually called a 'pressure transmission' test or a 'membrane efficiency' test. Examples of test methods/devices and results can be found in several references (Mody & Hale 1993, van Oort et al 1995, van Oort et al 1996, Ewy and Stankovich 2000, Stowe et al 2001, Schlemmer et al 2003a, Mody et al 2002, Ewy & Stankovich 2002, Schlemmer et al 2003b, Dye et al 2005). Most of these methods rely on similar principles to those used for measuring osmotic membrane behavior of compacted clays many years ago (e.g. Fritz & Marine 1983), although shale testing can be much more complicated. The early tests focused mainly on brines or brines with single additives, while later tests focused on multiple additives and/or more complete mud systems.

Depending on the device and test method employed, one can isolate just the osmotic pressure effects, or just the hydraulic effects, or measure the combined effects simultaneously. Some studies have focused mostly on development of high-osmotic-efficiency membranes, while others have focused mostly on physical plugging of shale pores, and some have focused on both. It could be argued that, to be truly effective, a water-base drilling fluid must be effective at both of these mechanisms.