Techniques help control shallow flow, isolate zones

DRILLING SHALLOW FLOW zones in the deepwater environment can be a formidable logistical and technical undertaking.

The key to understanding shallow water flows in any region is accurate pore pressure measurements.

Zonal isolation also has always been important in protecting groundwater and ensuring efficient well operation.

These subjects are explored in papers prepared for the "Shallow Water Flows and Zonal Isolation" session to be chaired by **D T Mueller**, **BJ Services** and **D Bond**, **Woodside Energy** at the 2001 SPE/IADC Drilling Conference.

MEASURING PORE PRESSURE

As part of the effort to understand the problem of shallow water flow (SWF) in the Gulf of Mexico (GOM) and to obtain data and develop design criteria for offshore production structures, geotechnical wells were drilled in several different prospects.

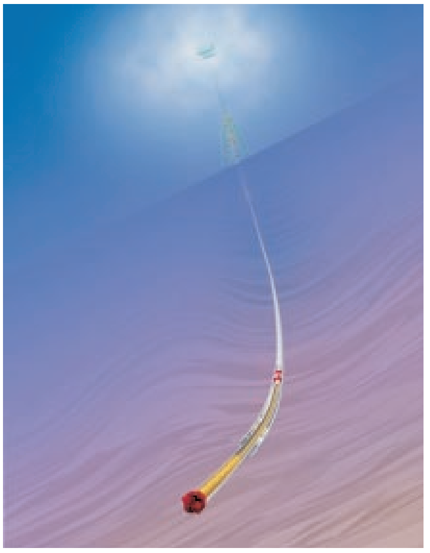
The prospects cover a 200-mile swath across the central deepwater GOM where SWF control problems have been experienced. In these wells, pore pressure measurements, as well as core and other in situ measurements, were taken in the deepwater shallow sediments.

Paper 67772, "Trends in Shallow Sediment Pore Pressures—Deep Water Gulf of Mexico," describes this data collection effort.

The authors, **R M Ostermeier**, **J H Pelletier**, **C D Winker** and **J W Nicholson**, **Shell International Exploration and Production**, cite the following facts and observations from the measurements.

A majority of the pore pressure measurements were made in low permeability clay-rich material predominant in the shallow sediments. Some measurements were near more permeable sand and silt zones. A few measurements were made in sandy/silty intervals.

Where significant overpressures were present they were found to begin at or very near the mud line, and to increase more-or-less linearly with depth below the mud line.



Young, soft formations in the first few thousand meters below the seafloor present special drilling and well control challenges. Illustration is courtesy of *Oilfield Review*.

Overpressures in the shallow sediments of the central deepwater GOM are due primarily to rapid sedimentation rates generated by the Mississippi River depocenter.

Regional trends in overpressures also correlate with drilling experience and the incidence and severity of shallow water flow occurrences. The degree of overpressuring is consistent with sediment porosity based on core measurements.

There are exceptions to these general regional trends. Most notable is that overpressures in shallow permeable sand or silt zones may not be in equilibrium with their bounding shales. Thus well location (up dip, down dip), faulting, fracturing and other factors need to be considered in predicting pore pressure in these permeable zones.

DRILLING SWF ZONES

Even under the most ideal conditions, drilling shallow flow zones in the deepwater environment can be a formidable logistical and technical undertaking.

Drilling Conference paper 67773, "Using Conventional and Unique Methods to Drill a Technically Demanding Shallow Flow Zone," describes the successful drilling of a prospect on Green Canyon Block 228. The paper was prepared by **P R Roller** and **M D Magner**, **Ocean Energy**; and **R M Drury**, **M-I LLC**.

In it, the authors focus on a well in 3,156 ft of water that was to be drilled through a shallow flow zone using an upgraded semisubmersible rig with limited drilling fluid storage capacity. Because of that limited capacity, additional logistical support was required.

Methods used to drill the shallow flow zones included the use of sophisticated hydraulics software to maintain the equivalent circulating densities (ECD) required to inhibit the flow while simultaneously drilling to casing point.

Even with the additional standby logistical support, using an upgraded semisubmersible saved the operator approximately 50% compared with the cost of a drillship for this interval.

The success achieved in the shallow flow zone enabled the casing points to be pushed down, thereby elevating fracture gradients at each interval and eliminating the 9⅝-in. liner.

DEEPWATER CEMENTS

More and more drilling occurs in frontier areas and in deep water. In this environment, where the water depth often ranges between 1,000 and 3,000 m, the temperature at the sea bed is extremely low, reaching -1 ºC (30 ºF) or less in certain parts of the world.

In addition, a non-linear temperature gradient in this water column and sea current further accelerate the cooling of the injected fluids.

In paper 67774, prepared for the Drilling Conference by **N Mohammedi**, **A Ferri** and **B Piot**, **Schlumberger**, the authors suggest that light weight cement systems can meet these unique challenges. In their paper, "Deep Water Wells Benefit from Cold Temperature Cements," the authors note that the formations encountered in the first few thousand meters below the sea floor preclude the use of normal density cement slurries.

However, conventional low-density cements do take a long time to set and develop any significant strength at those low temperatures. And the daily rate of the rigs able to drill those deepwater wells is fairly high.

It is therefore important to have lightweight cement systems that set quickly and develop high strength.

Often the permeable layers below the seabed contain either free gas when the water depth (and pressure) is reasonable, or gas hydrates at greater water depth. The lightweight cement system used in deepwater wells must therefore also contain gas during its setting process.

The authors describe experiences from the Black Sea and West Africa, where lightweight cements capable of setting quickly and managing gas flow in cold temperatures have been required.

Those systems are compared to more conventional solutions that have been applied or attempted for cementing the shallow casing strings in wells drilled in water depths ranging from 800 m to 1,900 m. Applications for water depths down to 2,800 m are also considered.

SEALING VENT FLOWS

In the western Canadian sedimentary basin, tens of thousands of wells currently are leaking gas between the surface and production casings.

That is the assessment of **H Slater**, **PanCanadian Petroleum**; and **D Stiles** and **W Chmilowski**, **Schlumberger Dowell**, authors of Drilling Conference paper 67775, “Successful Sealing of Vent Flows with Ultra Low Rate Cement Squeeze Technique.”

While much work has gone into preventing gas vents during primary cementing, little has been done to improve the chances of successfully sealing existing leaking wells, according to the authors.

The work described in their paper focuses on new materials and techniques that have been developed to seal vent flows.

Microannular gaps as narrow as 100 microns can allow gas leakage. The authors report that they have developed special optimized microcement systems to penetrate such narrow gaps.

These systems rely not only on very small particle sizes to eliminate bridging in narrow gaps, but also on slurry properties of extremely low filtrate loss and very low viscosity. Filtrate loss must be controlled both perpendicular and parallel to the axis of the gap to prevent dehydration and bridging.

Further, the filtrate loss must be controlled by a mechanism that is not wall-building. The slurry viscosity must be kept very low, minimizing the pressure drop through the gap that leads to dehydration and bridging.

The technique used to place the slurry is also a key parameter in the success of sealing vent flows.

Finally, once the slurry is in place it must remain there undisturbed until it sets to form a permanent seal.

SHALLOW CASING

In contrast to leak-off testing in deep wells, leak-off plots from the shallow sections subsea are inconclusive because there is no obvious point of deflection from the initial section of the plot. In SPE/IADC paper 67777, “Shallow Casing Shoe Integrity Interpretation Techniques,” prepared by **D Zhou** and **A K Wojtanowicz**, **Louisiana State University**, the effects of geo-mechanical factors and fluid loss mechanisms are combined to explain these tests.

Based on theoretical analysis, non-linearity of the pressure-volume plots is induced by combined effects of plastic horizontal fracture, cement parting and mud filtration into the rock. A mathematical model of a leak-off test is presented.

Maximum pressure of fracturing or cement parting is suggested as the leak-off point for shallow sediments. The effect of filtration can be removed to find the leak-off point. Interpretation procedures combine well data with the pressure testing record.

Well data includes overburden pressure, pore pressure, pressure during cement setting and offset well data. The testing record includes analysis of pressure buildup, break down and stabilization leveling off. ■