Wellbore stability

SPE/IADC 52866

"'Keep It Simple' Approach for Managing Shale Instability"

Wellbore instability, experienced mainly in shale sections, may be induced by either in-situ stresses that are high relative to the strength of ft formations (stress-induced) or physico-chemical interactions of the drilling fluid with the shale or a combination of both. This paper describes an efficient, 'keep it simple' approach to the management of shale instability. It takes into consideration the factors which determine whether conducting a stress-induced wellbore stability analysis would be sufficient or complex time-dependent drilling fluid-shale interaction mechanisms need to be taken into account in the development of a mud weight program which would provide the required effective mud support with time.

A range of wellbore stability analytical tools, ranging from simple stress-induced to complex time-dependent which enable an efficient approach for managing shale instability are described systematically. They include practical guideline charts for stability analysis, optimum wellbore profile and wellbore drillability which utilise both proven drilling fluid-shale interaction mechanisms and rock mechanics principles. The pragmatic utilisation of a shale database, key shale property correlations and design charts of pore pressure change due to drilling fluid-shale interaction mechanisms in designing optimal drilling fluids is also described.

Wellbore stability analysis and guidelines for efficient management of shale instability using the various analytical tools and design charts are described systematically. They are demonstrated through field case studies to develop strategies to control instability in horizontal wells in the North West Shelf of Australia Analyses were also carried out to highlight the effects of shale and drilling fluid properties on time-dependent wellbore (in)stability based on field conditions and formation properties in the region. The information presented in the paper provides a practical tool for optimising the approach in developing the solution, including drilling fluid design (weight, type and chemistry), to manage shale instability efficiently.

—C P Tan, X Chen, CSIRO Petroleum, et al

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"Minimizing Drilling Risk in Extended Reach Wells at Valhall Using Geomechanics, Geoscience and 3D Visualization Technology"

In the Valhall field in the North Sea, significantly resources have been located in the flanks of the field. In this situation the reservoir targets are the only driver for the wellbore trajectory planning. Even if all of the traditional drilling issues have been addressed and the well can be drilled on the paper, the wellbore can experience wellbore stability problems (lost circulation, stuck pipe, tight hole). The wellbore problems can progress very gradually so that they occur after a certain openhole exposure time or occur very rapid. The problems are also "lubricated" by a chemical mud properties.

Wellbore stability models, using offset drilling information, indicated early in the planning at Valhall that the drilling of the extended reach wells in the field was going to be a challenge. This challenge is ft result of a narrow safe operational mud pressure window that gets progressively narrower with increased wellbore sail angle.

'Me flank locations require sail angles close to 75 degrees in the overpressured unconsolidated claystone/shale of Tertiary age. The record to date has been 74 degrees. On this record well 3 MM USD was spent on fighting wellbore stability problems (750 hours). Since traditional wellbore stability analysis have already indicated high risk for instability, and sonic wells have been successful, while others not, we decided to develop a new approach. We wanted to look at potential rock strength changes that could not be picked up using offset well information in the planning. Our approach was to develop a more detailed geological model for the overburden with geologic surfaces and 3D coherency data. We then started to correlate drilling problems along wellbores in the 3D data cube. The 3D data presentation was done in a standard visualization software. The paper will present the geomechanical theory behind wellbore stability problems in fault zones and fractured rock mass, how the geologic model has been developed and how we use the visualization software to select a wellbore trajectory with the lowest risk of wellbore instability problems. We will also include some case histories that illustrates the potential this methodology has for reducing unscheduled events due to wellbore instability problems while drilling.

—T G Kristiansen, et al, Amoco Norway Oil

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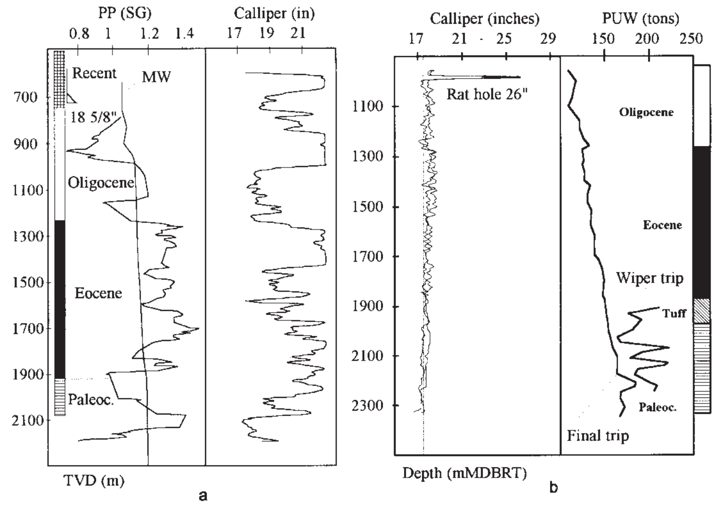
"Borehole Stability Assessment Using Quantitative Risk Analysis (QRA)"

Traditionally, wellbore stability assess-



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ments have been limited to deterministic analyses that yields wellbore pressures for the onset of tensile and/or compressive shear failure at the wellbore wall. These analyses have proven to be valuable for well planning and in

explaining wellbore stability related drilling problems seen in the field. However, these analyses have been of limited practical use because they establish limits for classical rock mechanics failure rather than limits for operational failure. Significant wellbore failure can be tolerated in near vertical wellbores without detriment to the success of the drilling operation. Due to more complex cuttings transport processes the tolerance for instability is much lower in highly deviated wells. Difficulty in obtaining accurate model input parameters has also precluded wellbore stability analyses from routine field applications.

A new wellbore stability analysis method based on QRA principles is described in this paper. Limit state functions for failure (stuck pipe due to breakout) and success (operationally tolerable magnitudes of breakout) are defined as functions of well trajectory and geometry. Stochastic input data for QRA, which incorporate uncertainties in model input parameters, are generated by a fully three-dimensional wellbore stability model. Modeling results yield probability of success as a function of drilling fluid density. A field application of the method is presented to illustrate the viability of the analysis.

—S Ottesen, et al, Mobil Technology Co

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"How to Manage Wellbore Stability in the Vicking Graben Tertiary Shales by Using Mud Systems Environmentally Friendly

In the past, mud/shale interaction was assimilated as a purely chemical problem and very often, salts were added to the mud to minimise shale instability. The recent five years brought a new understanding of the mechanism.

Among the different parameters influencing wellbore stability, formation pore pressure is now recognised as a major one. In a permeable reservoir, the response to drilling in under balanced conditions (mud weight less than formation pore pressure) is a kick. In a low permeability shale the response is wellbore instability. However as shales generally exhibit very low cohesion, overbalanced conditions are not generally sufficient to ensure stability. With a conventional Water Based Mud (WBM) pressure equilibrium between well and formation fluids is quickly achieved (due to mud filtrate penetration) breaking down overbalanced conditions.

Ideally, the mud system has to act as a barrier preventing any fluid movement from the well to the formation but the shale has also to play as a semi-permeable membrane so a proper osmotic gradient establishes which in turn acts a a pressure overbalance. Silicate mud has been identified as such a "shale stabiliser" which can possibly replace OBM for drilling reactive shales. Diffusion laboratory tests have shown that Silicate Mud acts basically as a plugging agent but also confers to the shale a semi permeable membrane character allowing a proper osmotic flow to be installed.

This paper deals with the drilling of the Eocene shales (17 1/2 section) of the Dunbar field (Vicking Graben North Sea). In the past, this formation was systematically drilled with a conventional WBM in under balanced conditions. With such a mud system, the well was highly unstable, particularly in the Eocene shales. Following three remedial side tracks experienced over the last two years, an extensive study has been carried out. A careful analysis of sonic logs allowed an estimate of the average pore pressure in the Eocene to be made and to design an adapted overbalanced Silicate Mud system. The results currently obtained on 2 wells (20 and 30 degrees) are very encouraging By contrast to previous "under balanced" experiences, the hole was perfectly in gauge (the 2 wells were logged) and trips much easier (regular wiper trips to be performed to scrape the silicate deposit on the section freshly drilled). However, even in the case of a perfectly stable rock and to ensure a good hole cleaning, the well had to be flowed with a high flow rate (4000 I/min) and a properly adjusted rheology had to be used to avoid pack off problems. These results have now to be confirmed over a larger range of inclinations.

—P A Charlez, V Pradet, Total Oil Marine
–M Gregoire, Total SA