Geoscience I examines formation pressure testing

FORMATION TESTING

THE AUTHORS WILL introduce a new technology in which a logging while drilling (LWD) tool is used to pressure test a formation during the drilling process. The Formation Testing While Drilling (FTWD) or GeoTAP* tool uses a testing technique similar to wireline formation testers. A probe is extended to the formation and a small sample chamber is used to pressure test the formation. The drilling environment offers many new challenges to pressure testing, however.

Wireline tools require a great deal of interaction with the engineer, which is very limited in the drilling environment. Therefore, the new tool has up-link and down-link capabilities and is highly automated for test control. New data compression routines are described that enable not only some of the raw data to be transmitted, but formation permeability and test quality estimates to be obtained in real-time. An efficient algorithm is used down-hole to analyze the data where testing parameters and selected pressure data are transmitted to the surface in real-time for continuous monitoring of the test.

The drilling environment is more dynamic than is the case for wireline testers. This environment is modeled using a finite element simulator to show the effects these dynamics might have on pressure measurements. The results show that even in this highly dynamic state it is possible to obtain reliable pressure measurements.

The authors will present field data from the GeoTAP tool and compare it with wireline formation test (WFT) data in test wells. The new tool requires the drill pipe to stop rotating or sliding for about seven minutes per pressure test. During this time the pumps can be turned on or off. Most of the test results were taken with the pumps on. A "pumps on" GeoTAP tool field example will also be also presented. The results compare very favorably with WFT data in terms of the absolute pressure measurement, repeatability and accuracy. The field example demonstrates the robustness of the measurement with three repeat pressure tests that were taken at three different depth points where the pressures recorded were within 1 psi. Final conclusions will drawn regarding FTWD technology and its future direction.

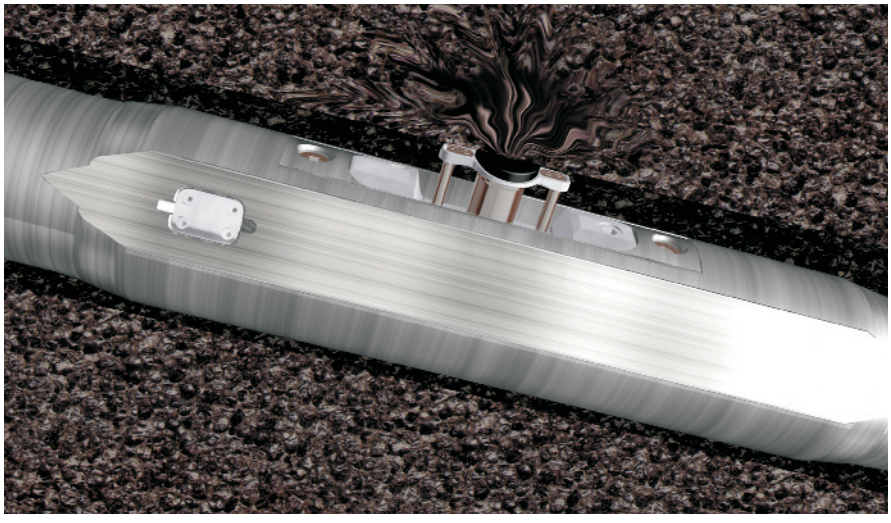
Formation Testing While Drilling: A New Era in Formation Testing (IADC/SPE 87090) **Mark A Proe**tt, **Michael Walker**, **David Welshans**, **Charles G Gray**, **Halliburton Energy Services**.

PRESSURE TESTING

Formation pore pressure is a key parameter for reservoir description. However, the pressure measurement traditionally performed in highly deviated or horizontal wells with drill pipe-conveyed wireline tools is time consuming. To provide the service earlier, a formation pressure tester has been developed as part of an LWD bottom hole assembly.

To meet the challenges of short station duration and limited telemetry rates, the new tool is equipped with a downhole intelligent system for real-time operational decisions. The flexibility of the tool's design allows basic pressure tests with preset draw down and build-up tests with preset fixed volume and rate, or repeated draw down and build-up tests with different drawdown rates and volumes optimized downhole in real-time.

In this first trial of the tool in a commercial well the longevity and repeatability of the tool were tested. The major requirement of the pressure data acquisition was to define the pressure profile of the well for application in the completion design. In the proximal section of the well, a zone of low pressure was identified as predicted. The real-time data quantified the reservoir pressure which allowed the drilling engineers to optimize the mud program and complete the drilling of the well efficiently. The tool performed extremely well and subsequent data analyses supported the real-time pressure measurements.



A new formation pressure tester was developed equipped with a downhole intelligent system for real time operational decisions to meet the challenges of short station duration and limited telemetry rates. IADC/SPE 87091

There have been 142 pressure tests performed at 64 different depths along the 13,693 ft reservoir section. Drilling was completed in two bit runs in 204 rotational hours during which the angle was built from 66° to 90° with a maximum dogleg of 3.5°/100 ft.

The successful operation of the tool resulted in considerable time andcost savings due to optimized drilling of the well, the cancelled pipe-conveyed logging job and in the running of the planned completion.

Field Experiences with a New Formation Pressure Testing During Drilling Tool (IADC/SPE 87091) **Soren Frank**, **Vin-**

cent Beales, **Stig Dilling**, **Maersk Oil & Gas**; **Matthias Meister**, **Jonny Haugen**, **Baker Hughes INTEQ**; **Jaedong Lee**, **Baker Atlas**.

LWD PRESSURE TESTER

Total Exploration UK, operating on behalf of Shell, ExxonMobil and Dana, is developing the Otter field in the North Sea. The development plan calls for three horizontal producers and two water injectors. Their location is critical to optimize production and reserves in this complexly faulted reservoir. The first well started producing in October 2002. The reservoir model assumed fault transmissibility and predicted that there would be a small but measurable depletion by the time the third well was drilled. When this well was entering the reservoir in January 2003, it was important to determine whether the reservoir draw down matched the reservoir model. Formation pressure information was required as soon as possible, as this would have implications on drilling the third well and possibly on the relocation of one of the injectors. Since this well was penetrating the reservoir section sub-horizontally, any wireline formation tester would have to be run on drill pipe. To reduce time and cost, an innovative technology, the Drilling Formation Tester (DFT), was utilized to gather the formation pressure data.

The DFT is an LWD tool that performs a formation pressure test using a dual packer configuration and a quartz gauge. It uses mud-pulse telemetry to transmit the downhole formation pressure data to the surface in real-time. Multiple pressure tests can be performed to measure formation pressure and from establish the formation fluid gradient. A formation evaluation LWD suite was run with the DFT. This allowed to geosteer the well into the optimal part of the reservoir and to investigate the reservoir pressure regime while drilling the well. This combination of LWD tools facilitated, while drilling, a comprehensive understanding of the reservoir, its fault compartments and pressure regime.

The real-time pressure data indicated that the well was located in a high permeability layer, confirmed the reservoir pressure model and facilitated the real-time decision-making process. The use of an LWD formation pressure tester was economic by saving an extra trip in the hole that would be required to acquire drill pipe conveyed wireline pressure data. It reduced operational risks and costs for data acquisition.

An LWD Formation Pressure Tester Tool (DFT) Refined the Otter Field Development Strategy in the North Sea (IADC/SPE 87092) **Jon Hill**, **E Mitchell**, **D Bowles**, **Pathfinder Energy Services**; **Gordon Holm**, **J N Furgier**, **C Longis**, J **F Roux**, **Total Exploration UK**.

NUMERICAL MODELS

The authors will present the analysis methods and modeling results from several types of software models in a post-well study of a lost circulation/flow event in a challenging high pressure high temperature (HPHT) exploration well. The effects of well conditions such as pressure and temperature changes on rock mechanical properties and geo-pressures will be reported. Results from a new lost circulation FEA (finite element analysis) model also helps explain why various formation-sealing treatment systems (some conventional and others new) failed to reduce the losses into the loss zones. Eventually, a new frac gradient enhancement squeeze system (FGESS) was implemented and it effectively halted the losses. Full circulation was then re-established to stabilize the well. The well had been losing at an equivalent circulating density of 16.4 ppg. Application of the FGESS treatment increased the wellbore pressure containment integrity to sustain an equivalent of 17.0 ppg mud as measured by a formation integrity test.

A new FEA model that uses formation stress log data to calculate fracture gradient enhancements by a FGESS will also be included to help show how the fracture gradient was increased. Upon re-entry of the well seven months after the successful FGESS treatment, the seal in the loss zones was still holding against HPHT conditions. This sustained seal saved even more costs and allowed a liner to be set without losses for a successful completion of the well. The conclusions of the study can help optimize well plans for future wells in the area which can lead to lower costs for drilling fluids, casing design, cementing, and completion equipment.

Numerical Models Help Analyze Lost Circulation/Flow Events and the Frac Gradient Increase by a Chemical Treatment to Control a HPHT Well in the East Mediterranean Sea (IADC/SPE 87094 – Alternate) **Medhat Sanad**, **Carl Butler**, **BP**; **Syed Arshad Waheed**, **Halliburton Overseas Limited**; **Ron Sweatman**, **Bob Engelman**, **Halliburton Energy Services**.