Challenges rise as exploration goes deeper

ANISOTROPIC ROCK STRENGTH

BASIC WELLBORE STABILITY modeling has been successfully used in the past but may prove inadequate because the mechanism of borehole failure and characterization of fracturing is not sufficiently addressed. In certain cases, a more complex geomechanical model is required. We describe an example where a complex geomechanical model was applied to address anisotropic wellbore failure, lost circulation, and to predict mud weights.

Anisotropic failure predominantly affects wells drilled at low angles of attack in weakly bedded formations. Near wellbore stress concentrations are controlled by well trajectory and far field stresses. Despite rock properties and stress magnitudes being beyond our control, we are able to design appropriate well trajectories and mud weights that prevent drilling problems.

Early appraisal drilling in a deepwater subsalt field resulted in significant wellbore instabilities. These were severe when drilling down dip at low angles of attack to bedding. Drilling operations experienced significant lost circulation when raising the mud weight to compensate for the instabilities. The high mud weights required to limit borehole collapse only increased the risk of losses in naturally depleted sands. The narrow mud window constrained the casing design, which resulted in severe cost overruns. The cuttings were characterized by blocky and platy cavings, which are not typical of normal wellbore instability due to shear failure. Anisotropic rock strength was diagnosed as the cause of wellbore instability, hence a sophisticated model was needed to explain this instability. Alternative mud weights, casing designs, well trajectories and locations were adapted, and the appraisal campaign was successfully completed with minimal wellbore stability problems.

Optimizing a Deepwater Subsalt Drilling Program From the Evaluation of Anisotropic Rock Strength Effects on Wellbore Stability and Near Wellbore Stress Effects on the Fracture Gradient (IADC/SPE 98227) A Brehm, C Ward, GeoMechanics Intl Inc; DW Bradford, DE Riddle, BHP Billiton.

DRILLING THROUGH THICK SALT LAYERS

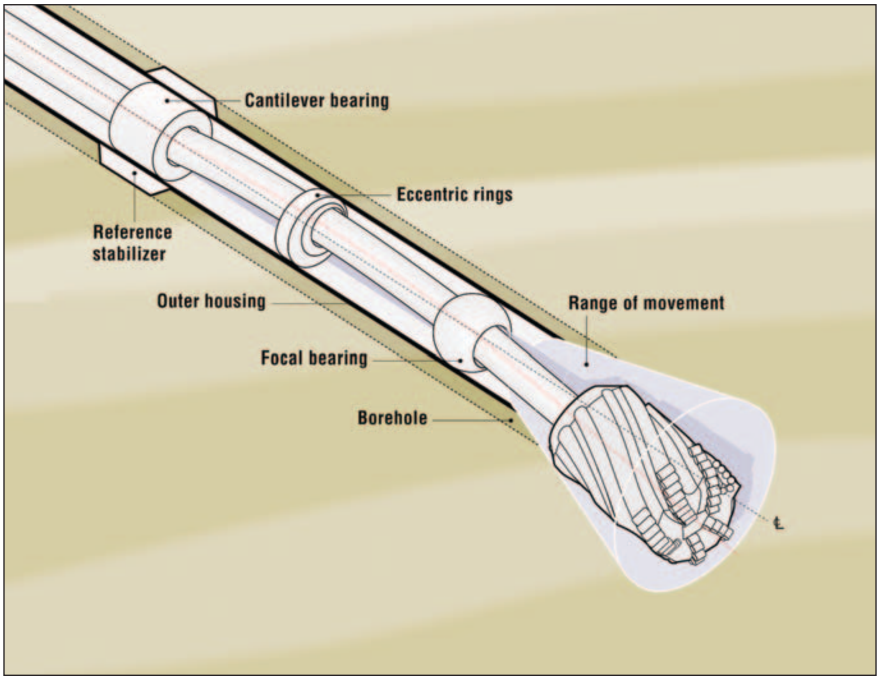
The presence of evaporitic sections in prospects for oil or gas exploration is, in itself, a factor that increases the probabilities of success in the area due to favorable conditions for the hydrocarbons generation and trapping. However, many operational problems such as stuck pipe and casing collapse have been reported when drilling through those salt layers. In the Campos Basin Brazil, several deep wells have been drilled through thick salt intervals. Up to the '90s, the lack of reliable ways to predict salt behavior at high temperatures and high differential stresses led to very high drilling costs and even loss of wells.

This paper presents a methodology for drilling fluid and casing design and drilling strategy for drilling at great depths through thick salt layers. The numerical simulations to evaluate the creep behavior of salt rocks submitted to high differential stress and high temperature were done through the application of an in-house finite element code developed.

Results obtained in prospect with 2,000m thickness of different evaporitic rocks with high creep rate was used to predict the evolution of the well closure with time for various drilling fluid and analyze several technically feasible alternatives to drilling strategy. The casing design was accomplished with several failure scenarios of cement the casing/borehole annulus through the salt, and drilling fluid in annulus to determine the non-uniform loading and timing of salt loading on well casings deformation or ovalization. The casing was designed to support high creep rate of carnalite and taquihydryte.

A recent application of this methodology in Campos Basin allowed us to drill this kind of well without a problem.

Well Design for Drilling Through Thick Evaporite Layers (IADC/SPE 99161) EJ Poiate, A Costa, JL Falcao, Petrobras.



98279: Eastern Canada, a harsh drilling environment, illustrates the need for flexible well designs that are able to respond to unanticipated drilling hazards and wellbore problems.

FLEXIBLE WELL DESIGNS

Modern-day oil exploration is pushing operators into harsher and more difficult drilling environments. Eastern Canada is one of those environments where deepwater and the need to penetrate thick salt sheets greatly increase the difficulty faced by drillers. This presentation describes a case history of deepwater, subsalt drilling, examines the requirements for success and details the challenges of pre-well planning for dealing with high pore pressures and variable fracture gradients.

This presentation highlights the need for flexible well designs able to respond to unanticipated drilling hazards and wellbore problems. Here the 11-in. casing was set 511m shallower than planned due to pore pressure increases. This had a significant effect later in the well construction program, requiring the use of unplanned expandable casing. The presentation illustrates on-the-fly modification of drilling designs to rapidly deploy unplanned equipment, the use of unconventional borehole sizes and newer technology. The presentation will also discuss the optimized use of hole openers as well as the use of expandable casing and the effects on hole openers of using expandable casing.

Results, observations and conclusions include:

1) Pre-well planning can differ considerably from practice once drilling commences and will be highlighted by the differences in pore pressure and fracture gradients;

2) Salt can be a cause of significant stress disruption and will be shown to be a significant influence on both near and far field stress regimes, significantly affecting fracture pressures;

3) This paper will highlight key learning success from new technology and how its application combined with real time well monitoring can optimize drilling to achieve success.

Pore Pressure Prediction and Drilling Challenges: A Case Study of Deepwater, Subsalt Drilling From Nova Scotia, Canada (IADC/SPE 98279) CN Marland, SM Nicholas, Halliburton; W Cox, C Flannery, B Thistle, EnCana Corp.

NATURAL HYDRATE RESOURCES

The Ministry of Economy, Trade and Industry (METI) of Japan has decided to carry out a 16-year research and development program of natural hydrate resources, and MH21, the research consortium of Methane Hydrate (MH) in Japan, has been active since 2001.

In 2004, the multi-well exploration campaign in the Nankai Trough was implemented as a national project led by METI. All scheduled programs were performed with deepwater research vessel the "JOIDES Resolution" operated by Transocean. There were 30 wells drilled for mainly geological research purposes and 2 wells drilled for engineering experiment purposes during this campaign.

The purpose of experiment was to obtain the engineering data and to verify technologies that would be required for future possible production from the natural hydrate offshore of Japan. The following experiment, which was 1) Drilling fluids applicability for borehole stability; 2) Monitoring the downhole pressure and temperature while drilling; 3) Cementing; 4) Formation/fracture pressure measurements; 5) Capability to horizontally drill unconsolidated formations and hydrate layers in very shallow section below the seabed, was conducted by drilling 2 wells in 19 days.

As a result of the experiment, effectiveness of the drilling fluids that were used for borehole stability was confirmed. The specially designed cement slurry covered up the hydrate formations. The pressure measurement executed at several points acquired effective data. The horizontal well was executed almost on the planned path and it was able to drill about 300m length of the hydrate layers, including 100m length of horizontal section at 340mTVD below the seabed.

Further research and development is scheduled.

Evaluation of Experiment Program 2004: Natural Hydrate Exploration Campaign in the Nankai Trough Offshore Japan (IADC/SPE 98960) M Matsuzawa, S Umezu, Japan Drilling Co Ltd; K Yamamoto, Japan Oil, Gas and Metals Natl Corp.

SAND CONTROL COMPLETIONS

World and Gulf of Mexico record setting extended reach sand control completions and interventions were successfully implemented in the Gulf of Mexico, Deepwater, Petronius Field. As unconsolidated pay sands were discovered further from the Petronius compliant tower, wells with consistently longer reach were used to develop additional reserves.

This paper describes the planning process for the completion operations along with the lessons learned while implementing these case history wells. Careful planning of procedures and equipment specifications are required to be successful. It will also compare and discuss the pre job modeling with the actual well results. A new, environmentally friendly, liquid friction reducing additive was successfully used in the completion brine to free the TCP string, which was at its tensile limit and could not be safely pulled.

Some of the completion challenges that will be discussed are:

1. High workstring torque, drag, and stretch;

2. Wireline run logs and packers using tractor technology;

3. Debris management (junk, perf debris, proppant, etc);

4. Sand control design, tools, and reverse out procedures;

5. High tubing drag, multiple control lines, and deep permanent BHP/BHT gauges;

6. Plugback to a selective sand control completion below 25,000-ft MD.

These deepwater case histories of extended reach sand control completions are applicable to other high angle completions regardless of water depth or completion type. This information will advance the understanding of the key issues for planning and execution of extended reach completions. It will also aid in the design of wells for future intervention.

Designing and Implementing Deepwater Extended Reach Sand Control Initial Completions and Interventions (IADC/SPE 98563) RD Pourciau, Chevron.

TRAPPED ANNULAR PRESSURE

ConocoPhillips is developing the Magnolia field with a Tension Leg Platform (TLP) in 4674 ft of water at Garden Banks block 783 in the Gulf of Mexico. The wells are completed using dry trees from the TLP.

99138: A new method of milling has been specifically designed to reduce milling and trip times in modern packers, which are being run with seal bore extensions instead of millout extensions.

The production casing for each well consists of an 8.062-in. liner set near the base of a 10.75-in. liner. The 10.75-in. liner is tied back to the subsea wellhead. The subsea wellhead is tied back the TLP with an 11.75-in. production riser. To minimize heat loss in the produced fluid above the mudline while flowing the well, the production riser x tubing annulus is filled with low pressure nitrogen. Completion brine is left in the well below the mudline. Two of the eight wells did not have cement behind the 10.75-in. liner hanger polished bore receptacle (PBR), leaving a trapped annulus.

Results from annular pressure build up programs and finite element analysis of the PBR tieback stem configuration indicated that the increased annular pressure due to temperature heat-up from production in combination with the reduced hydrostatic pressure of the nitrogen in the annulus could cause a collapse failure of the 10.75-in. liner hanger PBR. Since the tieback string had been run and cemented, it was not possible to access the annulus behind the liner hanger PBR by conventional means.

A number of potential solutions were considered: scab liner, expandable casing, perforate and squeeze annulus, low heat transfer gel instead of nitrogen and high density brine. This paper will discuss the analysis of the potential collapse issue, the potential solutions and implementation of the solution.

Liner Hanger Trapped Annular Pressure Issues at the Magnolia Deepwater Development (IADC/SPE 99188) LF Eaton, WR Reinhardt, ConocoPhillips Co; JS Bennett, Devon Energy Corp.

LESSONS FROM RONCADOR

During the last three years, Petrobras has experienced a sharp increase in the amount of ultra-deepwater operations.

Petrobras's UN RIO business unit Roncador asset, due to reservoir characteristics and production strategy, has implemented a unique configuration for its oil production and injection network. In summary, the Roncador asset decided to use pilot wells to tag the best positions within the reservoir.

By trying to re-use most of the pilot wells, the Roncador asset drills long horizontal extended sections, which are more than 1,000m long. Drilling those extended reach wells have provided Petrobras with many lessons and approaches.

This paper will share Roncador's drilling and problems in some noteworthy wells and the solutions found:

1) The use of Bent Housing of 1.2B0 with 9 5/8-in. motor with a shorter BHA would reach the dogleg 3B0 /30m and the required 800 gpm for proper cleaning in 16-in. wells.

2) Rotary Steerable, 16-in. customized PDC bits and synthetic mud together with 800 gpm prevented us from backreaming at the connections and at the end of phase;

3) Power drive collateral effect on increasing the shocks and slip stick;

4) Failure of MWD/LWD tools due to the increase of BHA shocks;

5) Importance of viscous cleaning pills;

6) Using FTWD (formation tester while drilling tools) with Rotary Steerable instead with power drive motors to reduce BHA shocks.

A Unique Experience in Roncador Asset: Drilling Conditions Faced in Order to Survive (IADC/SPE 98712) DA Meira, LP Barros, Petrobras.

PRODUCTION PACKERS

Most of the methods used today to remove a production packer from a wellbore are the same that have been in use for the last 30 or so years. These methods incorporate a shoe or milling head with a specific type retrieving tool to catch the packer after milling away the slips, and were designed for packers that came with millout extensions or blank bottoms. Today, however, packers are being run with seal bore extensions instead of mill-out extensions. Packers are being manufactured with more exotic materials and high chrome metals. These materials present a milling challenge; not only do they create longer milling times but they also usually require two or more trips to mill and recover the packer.

A new method of milling has been designed to reduce milling and trip times in these modern packers. This new method allows an operator to engage a smooth packer bore and completely remove all of the packer material and slips rather than removing only the outside material and leaving the packer mandrel. This milling procedure is quicker and produces smaller amounts of debris. The milling heads can be dressed with the most up to date cutting structures that will optimize the removal of the packer material, depending on whether it is standard grade or of a high tensile, high chrome content.

This paper will discuss the process and operational procedures pertaining to this new method, along with case histories.

Method To Reduce Milling and Trip Times During the Recovery Operations of Permanent Production Packers (IADC/SPE 99138) DB Haughton, P Connell, Baker Oil Tools. ■