Real Time Monitoring of Pore Pressure using an Effective Basin Model Approach

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Introduction

The high costs of a drilling operation for deep exploration targets (especially offshore) together with increased number and potential severity of drilling hazards put extra emphasis on the need to update the predrill prognosis in real time during drilling.

Established processes using quantitative calculations from drilling parameters and LWD data are standardly used to monitor PP during drilling. However the use of an Effective Basin Model (EBM) which can be quickly updated with real data during the drilling process adds an extra dimension to the RT monitoring work and we introduce here a short summary of the background and main application of such a tool.

The success of this application depends on the ability of the EBM to take in new information as it appears during drilling, be it revised formation top depths penetrated or ahead of bit, or the actual estimated PP constantly updated in realtime.
RT update of EBM

Data misfit plus mismatch in local geology as inputs for correction of the model
Advantages:
• Simple and unique link with the data
• Focused on prediction
• Quick prognosis production and updating during drilling

Disadvantages:
• Simple background model for single overpressure mechanism only
• Less reliable in real time when secondary overpressure mechanisms are active
Basin Modelling

Advantages:
• Sophisticated geo-model
• Accurate account for multi-mechanism of pressure generation
• Quantitative analysis of each component

Disadvantages:
• Weak link with the pressure-related data
• High non-uniqueness at calibration
• Low accuracy of pre-drill prediction
• Hard/impossible to use in during drilling
Effective Basin Model

**Advantages:**
- Key overpressure mechanisms are accounted in a flexible BM
- Data inversion routine provides proper BM calibration and optimal accuracy of prediction
- Quick BM updating allows real time pressure prediction ahead of the bit

**Disadvantages:**
- Creation and calibration of an effective BM is time consuming operation (especially for new region)
- Processing requires advanced user level
10 Steps to Pore Pressure Prediction before and during drilling

1. Collect available wells and get calibration area framed
2. Define the Area Stratigraphy Column
3. Build Framework Model
4. Introduce Fault System for Formation Model
5. 3D data integration
6. 3D pressure data analysis against Framework Model
7. Final adjustment of Framework Model against definitive multi-well dataset
8. BM matching against multi-well dataset
9. Pre-drill pressure prediction for a target well
10. Update pressure prediction in real time based on at-bit PP estimate
1-2: Get EBM calibration area with relevant wells and Define Stratigraphy Column

Regional aquifer formations
3-4: Build the Framework Model and Introduce Fault System for Formation Model
5-6: 3D Data Integration and Pressure Analysis vs Framework Model
7-8: Final adjustment of Framework Model against definitive multi-well dataset
9: Pre-drill pressure prediction for target well
10 RT Updating of EBM - General Workflow

Step 1. Get new data applicable for re-calibration of current background model

Step 2. Check current misfit between real data and their synthetic equivalent computed based on currently fitted model
   Case 1: The current misfit is acceptable. Stand by until new data portion come from well site. Go to step 1
   Case 2: The current misfit exceeds prediction error threshold. Go to step 3.

Step 3. Here the set of tunable model parameters are adjusted in order to reduce, to an acceptable level, the misfit between the actual PP estimate and the predicted PP

Step 4. Use updated synthetic overpressure curve below current drill bit position as an updated version of prediction
10: Realtime updating of pressure prediction
EBM as part of a PPwD process

Mud Logging
- DXC, TEMP, RPM, ROP, TORQ, MFI, MWI, MWO, GAS, MTI, MTO, Gas Peaks, Cavings, Drag, Fill, Swab, Surge, Shale Dens, Shale Factor, Reports

LWD
- DIR, GR, RES, DT, POR, DENS, ANNP, ESD, DWOB, DTORQ, TEMP

Wireline
- CALI, GR, SP, RES, DT, POR, RHOB, RFT, TEMP, POISS

Frequent updates of PP/CP/FP based on ALL data

Pre-drill Model
- Purpose-built Software

Geomechanics Model

Basin Model

Real-Time Drilling Data

Wellsite / Office Team

Pro-active changes to Well Plan

Depth-based & Time-based
Case history, Viking Graben 1996
Thank you – Any Questions?

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