Innovative Use of Petrophysics in Field Rehabilitation, with Examples from the Heather Field

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Innovative Petrophysical Methods

• Dynamic log curve repair
• Permeability prediction
• Saturation modeling
• Geosteering using saturation modeling
Genetic Algorithm and Fuzzy Logic (GAFL)

• GAFL - statistical methods that find relationships within datasets and use these to make predictions.

• A family of log curves from the same geological formation will have many physical characteristics in common, and relationships exist between, for example, core permeabilities and GR, RHOB, RT, DT.

• Proprietary software developed by Brovig-RDS and Aberdeen University to run GAFL within Paradigm Geophysical’s Geolog log analysis software.

• The processes are automatic and fast.
Fuzzy Logic Prediction Method

Sonic log
Gamma-ray
NMR
Other logs
Heather Field Examples of Curve Repair and Permeability Prediction

Light green areas denote extent of oil accumulation.
Dynamic Curve Repair

Hole washout

Tool failure

Hole washout
Permeability Prediction
Heather Field Saturation Modeling

FWL is free water level

- Structural closure ~12,800 ft TVDSS
- FWL~9,373 ft TVDSS
- FWL~10,470 ft TVDSS
- FWL~10,730 ft TVDSS

Extent of known oil pools
Saturation Modeling -
Foil Plot for North Terrace Wells 2/5-6 and 2/5-17 (1)

Free water level approx. 10,730ft TVDSS
Saturation Modeling - Foil Plot for North Terrace Wells 2/5-6 and 2/5-17 (2)

Note plot is in height above free water level

The fluid distribution can be completely described by only one variable!

FOIL function = $a H^b$
where $a=0.7873$, $b=-0.6513$, $H$ is height above free water level
Saturation Modeling - FOIL Plot for NW Heather

FWL approx.
12,800ft TVDSS?
Saturation Modeling - FOIL Plot from Main Field Blocks A, H & C

FWL approx. 11,550ft TVDSS
Saturation Modeling - FOIL Plots from Main Field including Crestal Wells

FWL ~ 10,470 ft TVDSS

FWL higher in crestal D & E Blocks

A, H & C Block
FWL approx. 11,550ft TVDSS
(previous slide)
Heather Field: Possible FWLs

- FWL ~ 12,800 ft TVDSS
- FWL ~ 10,730 ft TVDSS
- FWL ~ 9,373 ft TVDSS
- FWL ~ 10,470 ft TVDSS
- FWL ~ 11,550 ft TVDSS
Example Well CPI Comparing SW Calculated from Resistivity and Directly from FOIL Function

Swept zone - FOIL function computes initial saturations

Thin beds - FOIL function is probably a better measure of saturations than the resistivity tool

FOIL function accurately describes saturation in thick beds
Geosteering using Modeled Curve Data

- Determine free water level (FWL) in offset wells
- Build 3D model and extract curve data (GR, resistivity, density)
- Model for tool response and hole angle
- Back out resistivity/height profile
Resistivity vs Height Example
Resistivity Model Example for a High Angle Well

- **Compensated Waveform Resistivity**
  - R55A - Blue
  - R25A - Green
  - R55P - Red
  - R25P - Black

- **Anisotropy = 1**
- **Dielectric Constant = 10**

Wellbore Inclination = 81 degrees
Conclusions

- Fuzzy Logic is a powerful predictive tool with many rock property prediction applications

- Dynamic Curve Repair - LWD data are often lower quality than wireline data
  - Dynamic curve repair can bridge the quality gap

- Permeability prediction by Fuzzy Logic allows better choice of perforating intervals
  - It is still reliant on a good core permeability database

- The FOIL function is a simple and effective way of describing fluid saturations
  - It can help in thin beds and in wells where the resistivity tool was not run

- Saturation modeling with the FOIL function has many uses
  - Locate free water levels
  - Aid understanding of structural complexity
  - Identify swept zones
  - Can be used in geosteering to maintain a required distance from fluid boundaries
  - 3D reservoir modeling