GEOMECHANICAL APPLICATIONS TO OPTIMIZE THE DRILLING PERFORMANCE AT BELAYIM LAND OILFIELD, GULF OF SUEZ, EGYPT

By

Ali ElSayed Farag Farag Hammad

A thesis

Presented to Geophysics Department,
Faculty of Science, Ain Shams University
for the Ph.D. degree In
(Geomechanics)

Under Supervision of:

Prof. Dr. Ahmed S.A. Abu El-Ata
Geophysics Department, Faculty of Science, Ain Shams University

Prof. Dr. Said Abd El- Maboud Ali
Geophysics Department, Faculty of Science, Ain Shams University

Prof. Dr. Ashraf ElSayed Ghoneimi
Geology Department, Faculty of Science, Zagazig University

Cairo, Egypt,

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COMMITTEE APPROVAL SHEET

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ABSTRACT

Due to the location of Belayim land oilfield, where it lies on the eastern bank of the Gulf of Suez, a majority of wells are being drilled deviated from shore line, as well as vertical and horizontal wells to maximize the production and hydrocarbon recovery in the mature reservoirs of the study area. It is of great challenge to drill a high angle well successfully through a such complex structure and tectonic setting, especially the area is affected by hydrocarbon depletion with time and fluid migration while production. The stratigraphic setting of the area possesses significant drilling challenges that vary widely from salt creep and reactive shale to stress-related problems.

The objective of this thesis is to investigate, focus and integrate drilling, geologic and petrophysical knowledge for a better understanding the geomechanics of the study area, in order to select the optimal mud weight and to study the impact of stress orientation and magnitude, on the wellbore stability for safe drilling.

Practically, the drilling events such as the stuck pipe, kick and tight hole associated with the mud weight profiles can be used for better understanding the geomechanical setting of the concerned area.

A novel performance model is established on finding the relationships between the drilling parameters and the rate of penetration based on trigonometry, have been discussed in this study to find the most influential conditions on the rate of penetration. A new equation and a workflow to estimate the rate of

penetration in the hard rocks have been constructed, based on the sonic measurements.

In absence of the core chips to test the rocks for the mechanical properties, a set of relationships between the static elastic constants and the dynamic elastic constants are derived from the measurements of elastic wave velocities in the rocks and sonic logging .These data, in conjunction with the bulk density measurement permit, the in-situ measurements and calculations of the mechanical properties of the rock.

For enhancement the drilling performance of Belayim land oilfield through mitigating the risks, while drilling and production, a 3D mechanical earth model have been constructed through maximizing the values of the data integration by 3D grid and upscaled the petrophysical properties and lithology. Also, understanding the main causes of rock failure through 3D MEM resulted in improved drilling efficiency and reduced drilling costs.

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DEDICATION

This dissertation is dedicated to

Soul of my father

To my mother

To my wife

Finally to my children Salma, Rafik and Ahmad

NOMENCLATURES

Fs	= The horizontal force component with respect to the rock surface.
Fn	= The vertical force component with respect to the rock surface
A	= Cross sectional area of cut
E	= Drilling specific energy
S	= drilling strength
Ω	= Axial velocity of the bit
T	= The total torque
Tc	= Torque cutting term acting on the cutting face
Tf	=Torque friction term at the wearflats/rock interface
W	= Weight-on-bit
Wc	= Weight-on-bit cutting term acting on the cutting face
Wf	= Weight-on-bit friction term at the wearflats/rock interface
HPP	= Hydraulic horsepower
P	= Circulation pressure, psi
Q	= Circulating rate, gpm
IF	= Impact force, lb, at bit
MW	= Mud weight, ppg
Vn	= Jet velocity, ft/sec
Θwob	= Drilling resistance inclination per WOB
Θrpm	= Drilling resistance inclination per RPM
T	= Bit Torque (ft-lbf)
Db	= Bit size (inches)
WOB	= Weight on bit (pounds)
μ	= Bit –specific coefficient of sliding friction (dimensionless)
ΔTc	= the traveling time in μs/ft.
Δars	= the apparent rock strength (ARS) in psi
ROP*m*	= the rate of penetration - modeled in m/hr
ρ	= Density
ρb	= Bulk density of the formation (g/cm3)
DTCO	= Compressional slowness of the bulk formation
DTSM	= Shear slowness of the bulk formation
DTSM_C	= Computed DTSM
MR	= Modulus ratio
PR_DYN	=.Dynamic Poisson’s ratio
TSTR	= Tensile strength
E_dyn	= Young’s modulus dynamic
E_sta	= Young’s modulus static
G_dyn	=Shear modulus dynamic
G_sta	= Shear modulus static
K_dyn	= Bulk modulus dynamic
K_sta	= Bulk modulus static
σz	=is overburden stress

σ’	= total normal stress,
σ	= Effective normal stresses
τ	= Shear stress and P is pore pressure
Pp	= Predicted (shale) pore pressure
Pobs	= Overburden pressure (rocks and fluids)
Phyd	= Hydrostatic pressure (fluids)
Vo	= Interval velocity (ft/sec)
Vn	= normally compacted shale velocity (ft/sec)
Δtn	= Normal travel time (μsec)
Δto	= Observed travel time (μsec)
Cn	= Normal conductivity
CO	= Observed conductivity
Rn	= Normal resistivity
RO	= Observed resistivity
SH	= Maximum horizontal stress
Sv	= Vertical stress
Sh	= minimum horizontal stress
σ1	= The major field stress
σ2	= The intermediate Field stress
σ3	= The minor field stress
FG	= The fracture gradient
CSON	= Calibrated sonic in us/ft
RLA3	= Borehole Corrected Resistivity 3
RLA5	= Borehole Corrected Resistivity 5
GR	= Gamma Ray
DT4P	= Δ-T Compressional - Monopole P&S
DT4S	= Δ-T Shear - Monopole P&S
SPR4	= STC Slowness Projection, Receiver Array - Monopole P&S
HCAL	= HRCC Cal. Caliper
HCGR	= HNGS Computed Gamma Ray
HDRA	= HRDD Density Correction
HFK	= HNGS Formation Potassium Concentration
HSGR	= HNGS Standard Gamma Ray
HTHO	= HNGS Formation Thorium Concentration
HURA	= HNGS Formation Uranium Concentration
NPHI	= Thermal Neutron Porosity (Ratio Method)
PEFZ	= Standard Resolution Formation Photoelectric Factor
RHOZ G/C3	= HRDD Standard Resolution Formation Density
VPVS	=.Compressional to Shear Velocity Ratio
HFK	=.HNGS Formation Potassium Concentration
HSGR	=.HNGS Standard Gamma-Ray
HTHO	= HNGS Formation Thorium Concentration
HURA	= HNGS Formation Uranium Concentration
UCS	= Unconfined compressive strength (psi)

CONVERSION FACTORS

Ft x 3.048*E-01	= m
Mpa	= 145 psi
Gpa	=103 MPa
Gpa	=106 kPa

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