WELL BORE STABILITY: CAUSES AND CONSEQUENCES IN ABU MADI FIELD, OFFSHORE NILE DELTA, EGYPT.

A Thesis

Submitted to Geophysics Department, Faculty of Science, Ain Shams University for Partial Fulfillment of the Requirements for Master Degree in Science in Geophysics

(Geomechanics)

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NOTE

The present thesis is submitted to Geophysics Department, Faculty of Science, Ain Shams University in partial fulfillment of the requirement for the degree of Master in Science in Geophysics.

Beside the research work materialized in this thesis, the candidate has successfully passed the final examinations of the post-graduate courses covering the following topics:

1. Geophysical field measurements.
2. Numerical analysis and computer programming.
3. Petrophysical properties of rocks.
4. Advanced well logging.
5. Formation evaluation.
6. Reservoir evaluation.
7. Subsurface geology.
8. Geophysical prospecting.
9. Sedimentary basin analysis.
10. Fluids dynamics.

In fulfillment of the language requirement of the degree, the candidate also passed the final examination of a course in the English Language.

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ABSTRACT

Due to the location of Abu Madi gas field, where it lies on the northeastern bank of the Nile Delta, a majority of wells are being drilled deviated from shore line, as well as vertical 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 complex structure, tectonic setting and highly stressed shale. The stratigraphic setting of the area possesses significant drilling challenges that vary widely from 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 estimate pore pressure and fracture gradient, select the optimal mud weight window 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, mud losses and tight hole associated with the mud weight windows can be used for better understanding the geomechanical setting of the concerned area.

Some relationships between elastic moduli and rock strength have been discussed in this study to find the most influential conditions on the formations for safe drilling and to estimate equations for these moduli in the area of study.

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, sonic logs and density logs. 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 Abu Madi gas field through mitigating the risks, while drilling and production, a 1D mechanical earth model have been constructed through maximizing the values of the data integration by upscaling the petrophysical properties and lithology. Also, understanding the main causes of rock failure through 1D MEM resulted in improved drilling efficiency and reduced drilling costs.

Key Words: Geomechanics- Pore Pressure - Mechanical Earth Model- Wellbore instability-Nile Delta- Abu Madi gas field.

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To

My Family

LIST OF ABBREVIATIONS

M	= A measured log value.
AG	= Air gap.
α	= Biot's poroelastic constant.
ρ_b	= Bulk density of the formation (g/cm^3).
Ksta	= Bulk modulus.
DTCO	= Compressional slowness of the bulk formation (μs/ft).
$\rho_{mudline}$	= Density at the sea floor or ground level.
ρ	= Density value.
D	= Diameter of drilling bit (inch).
DSI	= Dipole shear sonic imager.
ECD	= Equivalent Circulating Density.
ECD	= Equivalent Circulation Density of the mud (ppg).
D	= Fluid density (ppg).
$P_{breakdown}$	= Formation breakdown pressure.
P	= Formation fluid pressure.
FG	= Fracture gradient.
Φ	= Friction angle.
g	= Gravity.
Phyd	= Hydrostatic pressure (fluids).
σ_2	= Intermediate stress fields.
Vo	= Interval velocity (ft/sec).
Mn	= Log values read in the absence of over-pressure.
LSS	= Long spacing sonic tool.
LCM	= Lost Circulation Materials.
σ_1	= Major stress fields.
K	= Matrix stress coefficient.
S_H	= Maximum horizontal stress.
$\boldsymbol{\sigma}_H$	= Maximum horizontal stress.
S_h	= Minimum horizontal stress.
$\boldsymbol{\sigma}_h$	= Minimum horizontal stress.
σ_3	= Minor stress fields.
ML	= Mud line depth.
NGR	= Natural Gamma Ray.

NPT	= None Productive Time.
GH	= Normal hydrostatic gradient (ppg).
λPn	= Normal pore-pressure gradient.
Δtn	= Normal travel time (µsec).
M/Mn	= Normal trends.
Vn	= Normally compacted shale velocity (ft/sec).
$\Delta$to	= Observed travel time (µsec).
OBG	= Overburden gradient.
P_{obs}	= Overburden pressure (rocks and fluids).
σ_z	= Overburden stress(psi).
υ	= Poisson's ratio.
Pp	= Predicted (shale) pore pressure.
PP	= Predicted pressure gradient.
ρ	= Pressure supported by matrix (effective stress).
Vp	= P-wave velocity.
ROP	= Rate of Penetration (ft/hr).
RFT	= Repeat Formation Tester pressure.
rpm	= Revolutions per minute.
RPM	= Rotation speed of the rotary turntable (rpm).
R	= Shape factor.
Gsta	= Shear modulus.
DTSM	= Shear slowness of the bulk formation (µs/ft).
τ	= Shear stress.
$\boldsymbol{V_P}$	= Sonic compressional velocity.
V_S	= Sonic shear velocity.
Q	= Stress geometry factor.
σ'	= Total normal stress.
TVD	= True Vertical Depth (ft).
UCS	= Unconfined compressive strength.
σ	= Vertical effective stress.
Sv	= Vertical stress.
WD	= Water depth.
W	= Weight on bit (lb).
E	= Young's modulus.

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