RESERVOIR CHARACTERIZATION OF ABU ROASH "G" FORMATION FOR ENHANCED OIL RECOVERY IMPLEMENTATION

By

Mohamed Abdallah Mohamed Abdel-Naby

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Petroleum Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

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FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
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Title of Thesis:

Reservoir Characterization of A/R G Formation for Enhanced Oil Recovery Implementation

Key Words:
Western Desert, Abu Roash G, Enhanced Oil Recovery

Summary:

The motivation for preparing the research work is mainly to study the possibility of applying of Enhanced Oil Recovery (EOR) application on A/R G Formation of matured fields in the Western Desert. The EOR screening process, applied on two software applications, revealed that the chemical flooding, deterministically the surfactant polymer (SP), method is the most appropriate method to be applied on the A/R G Formation and an would reveal additional recovery factor of 7.4% and 8.0% for the most potential field A and B, respectively. The economic analysis of the study shown that the SP flooding is feasible if the crude oil price is higher than 41$/bbl for A/R G Formation.

Acknowledgments

I would like to extend thanks to the many people who so generously contributed to the work presented in this thesis.

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I would like to dedicate my thesis to my beloved wife, Samar Allam, not only for her support and encouragement throughout the study phases but also for inspiring me to accomplish this thesis throughout her MBA achievement. Also, for providing me with a suitable environment to complete this thesis. Without her I wouldn't start or finish this study.

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Finally, but not least, I'd acknowledge the efforts of my colleagues in Sahara Oil & Gas Co., specially Eng. Fady Nabil for helping me in the write up of thesis list of figures, and list of tables.

Dedication

I'd like to dedicate this work to two parties I'm the sole link between them:

To the soul of who I knew his death at 19:52 on Saturday, 7th January 2018... To the soul of my dear father

To those who I wish to be proud of me someday ... to the most precious persons in my life ... to Mourad and Yahya.

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Nomenclature

Abbreviations

3D	Three Dimensions
API	American Petroleum Institute
A/R G	Abu Roash "G" Formation
A/R LG	Lower Abu Roash " G" formation
A/R MG	Middle Abu Roash " G" formation
ASP	Alkaline-Surfactant-Polymer
BHP	Bottom Hole Pressure
CAPEX	Capital Expenditures, $
CFPM	Chemical Flooding Predictive Model
CO_2MF	Carbon Dioxide Miscible Flooding
CO_2IMF	Carbon Dioxide Immiscible Flooding
DFL	Dynamic Fluid Level
EGPC	Egyptian General Petroleum Corporation
EOR	Enhanced Oil Recovery
EUR	Estimated Ultimate Recovery, STB
FVF	Formation Volume Factor, bbl/STB
FZI	Flow Zone Indicator
GOR	Gas Oil Ratio. scf/STB
GPC	General Petroleum Company
GUI	Graphical User Interface
GUPCO	Gulf of Suez Petroleum Company
IMM	Immiscible Flooding
LoSal	Low Salinity
MP	Micellar - Polymer
NF	Natural Flow
NPV	Net Present Value, $
ODT	Oil Down-To, ft
OIP	Oil In Place, STB
OOIP	Original Oil In Place, STB
OPEX	Operating Expenditures, $
Petrobel	Belayim Petroleum Company
PPVI	Polymer Pore Volume Injected, fraction
PVT	Pressure-Volume-Temperature
RF	Recovery Factor, %
RFT	Repeat Formation Tester
SAGD	Steam-Assisted Gravity Drainage

Sal.	Salinity
SC	Surfactant Concentration, %
SCAL	Special Core Analysis
SP	Surfactant-Polymer
SSS	Surfactant Slug Size, fraction
STB	Stock Tank Barrel
TAP	Thermally Activated Particles
UB	Upper Bahariya formation
WC	Water Cut
WD	Western Desert

Parameters

Bg	Gas Formation Volume Factor , bbl/scf
Bgi	Initial Gas Formation Volume Factor, bbl/scf
Bo	Oil Formation Volume Factor, bbl/STB
Boi	Initial Oil Formation Volume Factor, bbl/STB
Cf	Formation (Rock) Compressibility, psi−1
Cw	Water Compressibility, psi−1
fw	Water Fraction, fraction
G	Initial Gas-Cap Volume, scf
Ginj	Cumulative Injected Gas, scf
Gp	Cumulative Produced Gas, scf
K	Permeability, mD
Kr	Relative Permeability, dimensionless
Kro	Relative Permeability to Oil, dimensionless
Krw	Relative Permeability to Water, dimensionless
M	Mobility Ratio, dimensionless
m	Ratio of Initial Gas-Cap-Gas Reservoir Volume To Initial Reservoir Oil Volume, fraction
N	Original oil in place, STB
Np	Cumulative Produced Oil, STB
P	Volumetric Average Reservoir Pressure, psi
PHI	Porosity, %
Pi	Initial Reservoir Pressure, psi
Rp	Cumulative Gas-Oil Ratio, scf/STB
Rs	Gas Solubility, scf/STB
Rsi	Initial Gas Solubility, scf/STB
Soi	Initial Oil Saturation, %
Sor	Residual Oil Saturation, %
Sw	Water Saturation, %

WC	Water Cut, %
We	Cumulative Water Influx, bbl
WI	Water Injection
Winj	Cumulative Water Injected, STB
Wp	Cumulative Produced Water, bbl
Δp	Change In Reservoir Pressure = pi − p, psi

Greek Symbols

$	United States Dollar
µo	Oil Viscosity, Centipoise (cp)
µw	Water Viscosity, Centipoise (cp)

Abstract

With the increase in the energy demand and the slowdown in oil production, Egypt became a net oil importer in the early-2000s. In addition, oil is a strategic product that would add value to the Egypt income, in case of reversing the production – consumption relationship and Egypt become an exporter once more. There is no alternative to re-evaluate the Egyptian hydrocarbon assets to find out a way of bridging the gap between the production and consumption. The motivation for preparing the research work is mainly to put a milestone in studying the possibility of Enhanced Oil Recovery (EOR) application on A/R G Formation of matured fields in the Western Desert.

The first step in this research work was to analyze the characteristics of A/R G Formation in Western Desert in order to determine its suitability for application of the different Enhanced Oil Recovery (EOR) technologies. The area of the study includes seven Fields (from A to G) located in Abu El-Gharadig Basin.

The analysis of the results showed that Fields A and B are the most promising potential fields for EOR application. Each contains remaining Original Oil in Place (OOIP) more than 100 MMSTB. Screening procedure for the applicability of EOR processes were carried out using two software applications for verification of results: the “EORgui” and “Cairo University Screening Module”. The EOR screening process revealed that the chemical flooding, deterministically the surfactant polymer (SP), method is the most appropriate method to be applied on the A/R G Formation.

The study showed also that the application of such process in A/R G Formation in Fields A and Field B will reveal additional recovery factor of 7.4% and 8.0%, respectively. The economic analysis of the study shown that the SP flooding is feasible if the crude oil price is higher than 41$/bbl for A/R G Formation.