

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قال تعالى:

{ سَبِّحْ اسْمَ رَبِّكَ الْأَعْلَى \* الَّذِي خَلَقَ فَسَوَّى \*  
\* وَالَّذِي قَدَّرَ فَهَدَى \* وَالَّذِي أَخْرَجَ الْمَرْعَى \*  
فَجَعَلَهُ غُثَاءً أَحْوَى }

صدق الله العظيم

سورة الأعلى الآية ( 1 - 5 )

## *Dedication*

*For their countless sleepless nights filled with prayers and hopes for my success in life, the least I could do is to dedicate my efforts to the most influential people in my life  
Father, Mother, Sisters and brothers ...*

*The dedication extended to my family members, friends and colleagues.*

## *Acknowledgement*

*First and foremost I must thank "ALLAH" who provided me with power. I will till the end of this thesis, also I would like to express my profound gratitude to my parents for their kindness, carefulness along my life and the hard effort they did to get knowledge. Special and deepest thanks to my wife who supported me and provided me with good environment for finishing this job.*

*My appreciation to my supervisor : **Dr. Ali A. Rabah** without his help my task would have been more difficult, with his assistance he pointed me in the right direction to acquire correct information and helped me to finish this project successfully and I appreciate his kind cooperation and fruitful efforts.*

*I wish to thank warmly all my teachers for their valuable assistance throughout my university studies, they have done every things I could hope, special and great thank to **Dr. Sumaia AbdulMoneim**, post graduate supervisor.*

## Nomenclature

### Symbols

$B_o$	Oil formation volume factor (bbl/stb)
$B_{ofb}$	bubble-point oil formation volume factor
$B_g$	Gas formation volume factor (cft/scf)
$B_t$	Total volume factor
$M$	Molecular weight
$P$	Pressure, psi
$P_b$	Bubble point pressure, psi
$P_r$	Reservoir pressure, psi
$P_{wf}$	Flowing well pressure, psi
$q_o$	Oil Production Rate, STB/D
$R$	Universal gas constant
$T$	Temperature, $C^{\circ}, F^{\circ}$
$V$	Volume, $cm^3$
$\mu$	Viscosity, centipoises
$\rho$	Fluid Density, $\frac{gm}{cm^3}$
$\gamma_g$	Gas specific Gravity
$\gamma_o$	Oil specific Gravity
$Z$	Gas deviation Factor

## Abbreviations

TRES	Reservoir temperature ( $^{\circ}\text{F}$ )
PBP	Bubble point pressure (saturation pressure) (psig or psia)
PDP	Dew point pressure (saturation pressure) (psig or psia)
VS	Volume of the sample at cell temperature and pressure
VBP	Volume of the sample at bubble point pressure
VDP	Volume of the sample at dew point pressure
V <sub>sat</sub>	Volume at the saturation pressure
GOR	Gas oil ratio Standard volume of gas/volume of sto (scf/stb)
GCR	Gas condensate ratio Standard volume of gas/volume of stock tank condensate (scf/stb),
LNG	Liquefied natural gas Calculated liquid volume of the gas component as liquid (bbl/mmcf)
PNA	Paraffins, naphthenes, aromatics
R <sub>s</sub>	Solution gas oil ratio scf/stb
R <sub>sfb</sub>	bubble-point solution gas-oil ratio
R <sub>l</sub>	Liberated gas oil ratio scf/stb
V <sub>rel</sub>	Gas in solution at p and T /volume of stock tank oil (scf/STB) Relative volume
V <sub>t</sub>	Total hydrocarbon volume
n <sub>g</sub>	Number of gas moles
n <sub>o</sub>	Number of oil moles
n <sub>c</sub>	Number of condensate moles
API	American petroleum institute
GOR	Gas-oil ratio
FVF	Formation volume factor
X-X	The studied Sudanese oil field
OOIP	Original oil in place
PVT	Pressure-volume-temperature
QC	Quality check
RF	Recovery factor
STB	Stock tank barrel
scf	Standard cubic feet
BHS	Bottom hole sample

## Abstract

The reservoir fluid properties is the key of oil reserve evaluation and production even using primary production or enhanced oil recovery methods. So we preferred to focus on some of the properties of crude oil that reflect the oil behavior under the pressure and temperature of the reservoir.

The objective of this research to know the properties of a Sudanese oil from new field and the type of it's fluid. And choose the best bubble point correlation which gives a reliable result compeered with the measured one from five correlations.

An experimental Study has been done for a Sudanese crude oil field recently discovered. From the study we get the result of the following properties bubble point pressure, relative volume, oil compressibility, gas oil ratio or solubility, viscosity, density, Z coefficient of gases liberated, oil and gas formation volumes factors, the specific gravity of gas, molecular weight of gas, and oil and gas compositions. According to these properties we describe this type of oil as black oil.

Finally we find that Standing correlation is the best computational methods to predict the bubble point pressure from the five methods, using data from various Sudanese oil fields (93) sample and analyze the results statistically based on the standard deviation and the percentage of errors and pressure difference for samples measured in the laboratory.

## تجريد

تعتبر خواص موائع المكامن النفطية مفتاح لتقييم المخزون النفطي وكيفية إنتاجه واستخلاصه بالطرق المحسنة لذلك فضلنا أن نلقي الضوء على بعض الخصائص لخام النفط التي تعبر عن سلوكه تحت ضغط وحرارة الخزان.

الهدف من هذا البحث التعرف على خواص الموائع النفطية لخام سوداني لحقل جديد ونوعه. وإختيار أفضل الطرق الحسابية للتنبأ بضغط الفقاعة التي تعطي نتائج مناسبة مقارنة بالمقاسة معمليا من ضمن خمس طرق حسابية.

تم عمل دراسة عملية كاملة لخام سوداني ضمن الحقول المكتشفة حديثا وحددت منها الخواص التالية ضغط الفقاعة، الحجم النسبي، إنضغاطية الزيت، نسبة الغاز للزيت أو الذوبانية، اللزوجة، الكثافة مععامل الحيوذ للغازات المتحررة، معامل التمدد الحجمي للغاز والزيت، الثقل النوعي للغاز، الوزن الجزيئي للغاز بالإضافة إلى مكونات الغاز والزيت. وبناء على هذه الخواص تم تصنيف هذا الخام على أنه من النوع الثقيل.

وأخيرا وجدنا ان طريقة إستاندنق الحسابية هي أفضل الطرق الحسابية للتنبأ بضغط الفقاعة من ضمن خمس طرق باستخدام بيانات من مختلف الحقول النفطية السودانية (93 عينة) وذلك بتحليل النتائج إحصائيا بناء على الانحراف المعياري والنسبة المئوية للأخطاء وفرق الضغط بالنسبة للعينات المقاسة معمليا.

## Table of Contents

Content	No.pag
آية من القرآن الكريم	I
Dedication	II
Acknowledgement	III
Nomenclature	IV
Abbreviations	V
Abstract	VI
تجريد	VII
Table of content	VIII
List of tables	IX
List of Figures	X
<b>Chapter One: Fundamentals Of Reservoir Fluid behavior</b>	
Objectives	1
Introduction	2
Pressure-temperature diagram	3
The five reservoir fluids	5-14
Collection of reservoir samples	15
<b>Chapter Two: Literature Review</b>	
Laboratory Analysis of Reservoir Fluids	16
Constant-composition expansion test	17
Differential liberation test	21
Separator tests	24
Bubble Point Pressure correlations	25-28
<b>Chapter Three: Research Methodology</b>	
Research Methodology	29
Raw Data	30 - 32
<b>Chapter Four: Result and Discussion</b>	
Result of PVT study for a Sudanese oil field (Bottom hole Sample )	33 -53
Result of Bubble Point pressure Correlation	54 -76
<b>Chapter Five: Conclusions And Recommendations</b>	
Conclusions And Recommendations	77
References	78
Appendix	79-80



## List of Tables

Table	Description	No.pag
3-1	Raw data used for analysis	30- 32
4 – 1	Summary Of Main PVT Data Bottom hole Sample (x-x)	33
4 – 2	Reported well and sampling Information Bottom hole Sample (x –x)	34
4 – 3	Quality Checks Of bottom hole Sample (x - x)	35
4 – 4	Atmospheric Flash test (zero Flash )	35
4 – 5	Compositional Analysis of Flashed gas , stock tank oil and Calculated well stream in Wt % bottom hole sample (x - x)	36
4 – 6	Compositional Analysis Of Flashed gas , Stock tank oil and Calculated well stream in Mole % bottom hole sample (x - x)	37
4 – 7	Reservoir Fluid Properties Bottom Hole Sample (x - x)	38
4 – 8	Constant Composition Expansion at 79 °C BHS (x - x)	39
4 – 9	Constant Composition Expansion at 79 °C BHS (x - x) Compressibility Calculation	40
4- 10	Thermal Expansion Factor at 5000 Psig Bottom hole sample (x – x)	40
4- 11	Summary of Differential Vaporization test at 79°C Bottom hole sample (x- x)	41
4 – 12	Hydrocarbon Compositional Analysis Of Liberated gas and Residual oil From Differential Vaporization @79°C bottom hole sample (x - x)	42
4 – 13	Oil Viscosity and gas viscosity at 79°C BHS (x - x)	43
4 – 14	Crude oil Physical Properties BHS (x -x)	44
4 –1 5	Standing correlation	55-57
4 – 16	Marhoun's correlation	58-60
4 – 17	Glazos's correlation	61-63
4 – 18	The petrosky-farshad correlation	64-66
4 – 19	The vasquez-beggs correlation	67-69
4 – 20	No. Of samples according to dp ranges for each correlation	70
4 – 21	Cumulative No. Of samples according to dp ranges	71
4 – 22	No. Of samples according to percentage error ranges for each correlation	72
4 – 23	Cumulative No. Of samples according to percentage error ranges	73
4 – 24	Statistical analysis	74

## List of Figures

Figure	Description	Page
1-1	Typical P-T diagram for multicomponent system	3
1-2	Phase diagram of a reduction of reservoir pressure, typical black oil	7
1-3	Phase diagram of a typical volatile oil	9
1-4	Phase diagram of a typical retrograde gas	10
1-5	Phase diagram of a, typical wet gas	13
1-6	Phase diagram of a typical dry gas	14
2-1	Constant Composition Expansion Test	19
2-2	Differential Liberation Test	22
4-1	Relative volume Vs. Pressure	45
4-2	Y Function Vs Pressure	46
4-3	Density Vs. Pressure	47
4-4	Viscosity Vs. Pressure	48
4-5	Calculated Gas Viscosity Vs. Pressure	49
4-6	Formation volume factor Vs. Pressure	50
4-7	Dissolved Gas Oil ratio Vs. pressure	51
4-8	Z factor Vs. Pressure	52
4-9	Gas Gravity Vs. Pressure	53
4-10	No. of samples according to dP ranges for each correlation	70
4-11	Cumulative No. of samples according to dP ranges	71
4-12	No. of samples according to percentage error ranges for each correlation	72
4-13	Cumulative No. of samples according to percentage error ranges	73
4-14	Maximum Values from percentage error for each correlation	74
4-15	Minimum Values from percentage error for each correlation	75
4-16	Average Values from percentage error for each correlation	75
4-17	Standard Deviation Values from percentage error for each correlation	76