## UNVEILING THE SUBSURFACE LITHOLOGIC ATTRIBUTES OF PIRKOH-1 AND PIRKOH-3 AREA BY USING PETROPHYSIC



By

EHSAN AMJAD

Department of Earth and Environmental Sciences Bahria Univeristy, Islamabad

2011

## UNVEILING THE SUBSURFACE LITHOLOGIC ATTRIBUTES OF PIRKOH-1 AND PIRKOH-3 AREA BY USING PETROPHYSIC



A thesis submitted to Bahria University, Islamabad, in partial fulfillment of the requirement for the degree of M.S in Geology

### EHSAN AMJAD

### Department of Earth and Environmental Sciences Bahria Univeristy, Islamabad

2011

#### ABSTRACT

The current study deals with petrophysical studies of wireline logs of well, Pirkoh 01 and Pirkoh 03 located in the Pirkoh area of Central Indus Basin, Balochistan. Main purpose of this thesis is to understand the hydrocarbon potential of Pirkoh 01 and Pirkoh 03 involving well logs interpretation using composite log suite that include Resistivity, NPHI (Neutron porosity), Gamma ray, acquired from Directorate General of Petroleum Concession of Pakistan (DGPC). Average shale volume of Pab Sandstone of Pirkoh 01 is 65%, total porosity is 13.15% and water saturation is 56% while Pirkoh 03 has average shale volume 49%, effective porosity ranges from 0-40% in Pab sandstone and water saturation is 59%. Petrophysical interpretations show the Pab Sandstone of Pirkoh 01 and Pirkoh 03 is gas bearing.

#### ACKNOWLEGEMENTS

I am indebted to my supervisor, Mr. Muhammad Zahid Geoscientest (LMKR) Islamabad and Mr. Anwar Qadir Assistant Professor Department of Earth and Environmental Sciences, Bahria University for their guidance and support to complete my thesis work.

I offer my sincere gratitude to the Prof. Dr. Tahseenullah Khan Bangash, of this department for the critical review of the thesis

Last but not least I am thankfull to Dr. Mohammad Zafar, Head of Department, Earth and Environmental Sciences, Bahria University Islamabad for making the arrangements of the supervisors.

### CONTENTS

ABSTRACT	i
ACKNOWLEDGMENT	ii
CONTENTS	iii
FIGURES	vii
TABLES	viii

### **CHAPTER 1**

### **INTRODUCTION**

1.1	Pirkoh gas field	1
1.2	Well data detail	2
1.3	Geology of area	4
1.4	Tectonics of area	5
1.5	Structure present in area	5
1.6	Stratigraphy	6
1.6.1	Pirkoh limestone	6
1.6.2	Sirki shale	6
1.6.3	Habib Rahi limestone	7
1.6.4	Ghazij Formation	7
1.6.5	Dunghan Formation	7
1.6.6	Upper Ranikot (source and seal)	7
1.6.7	Lower Ranikot (reservoir)	8
1.6.8	Pab Sandstone	8
1.6.9	Fort Manro	8
1.6.10	Parh limestone	9
1.6.11	Upper goru	9

1.6.12	Upper shale unit (lower goru)	9
1.6.13	Shale unit (lower goru)	9
1.6.14	Sembar shale (source)	10
1.6.15	Chiltan limestone	10
1.7	Petroleum prospects	12
1.8	Plays in study area	13
1.8.1	Source rock	13
1.8.2	Reservoir rock	13
1.8.3	Seal rock	13
1.8.4	Hydrocarbon types	13
1.8.5	Overburden rock	13

#### **CHAPTER 2**

#### **MATERIALS AND METHODS**

2.1	Wireline logging	15
2.2	Types of well logging	15
2.2.1	Open hole logging	15
2.2.2	Cased hole logging	16
2.2.3	Production logging	16
2.3	Logs used for study of Pirkoh well 01 and 03	16
2.3.1	Gamma ray	16
2.3.2	Neutron log	17
2.3.3	Density log	17
2.3.4	Resistivity logs	18
2.3.4.1	Lateral focus log	18
2.3.4.2	Induction log	19
2.3.4.3	Micro resistivity log	19

2.4		10	
2.4	Petrophysical interpretation	19	
2.4.1	Porosity	21	
2.4.1.1	Primary porosity	21	
2.4.1.2	Secondary porosity	21	
2.4.1.3	Effective porosity	21	
2.4.2	Permeability	21	
2.4.2.1	Absolute permeability	21	
2.4.2.2	Effective permeability	22	
2.4.2.3	Relative permeability	22	
2.4.2.4	Dual permeability	22	
2.4.3	Water saturation	22	
2.4.4	Volume of shale	23	
2.4.5	Determination of volume of shale	23	
2.4.5.1	Volume of shale by gamma ray log	23	
2.4.5.2	Volume of shale by sp log	24	
CHAPTER 3			
PETROPHYSICAL INTERPRETATION			
3.1	Interpretation of Pirkoh well 01	26	
3.1.1	Interpreted well log of Pirkoh 01	27	
3.1.2	Well zonation of Pirkoh 01	28	
3.2	Petrophysical parameters	29	
3.2.1	Volume of shale	29	
3.2.1.1	Shale volume at depth 7320 feet	30	
3.2.1.1	Shale volume at depth 7400 feet	30	
3.2.2	Porosity calculation	30	
3.2.3	Calculation of Formation water resisivity	31	

3.2.3.1	Rw at depth 7500 feet	32
3.2.4	Archie water saturation equation	32
3.2.5	Saturation of hydrocarbon	33
3.2.5.1	Pickett plot or saturation cross plot	33
3.3	Cross plot	37
3.3.1	Porosity vs depth plot of Pirkoh 01	37
3.3.2	Sonic vs density plot for Pirkoh 01	38
3.3.3	Neutron porosity vs density plot for Pirkoh 01	39
3.3.4	Volume of shale vs density plot for Pirkoh 01	40
3.3.5	Resistivity volume of shale plot for pirkoh 01	41
3.3.6	Sonic vs neutron porosity plot for Pirkoh 01	42
3.4	Sand shale analysis	43
3.5	Interpretation of Pirkoh well 03	45
3.6	Graphs	45
3.6.1	Graph of Pirkoh 03	46
CONCLUSIONS		48

RECOMMENDTIONS	49
REFFERENCES	50

### **FIGURES**

Figure 1.1	Showing location of Pirkoh gas field	2
Figure 1.2	Generalized geological map of Sulaiman sub basin	5
Figure 1.3	Showing generalized stratigraphic column	11
Figure 1.4	Central Indus basin and subdivision into petroleum zone	12
Figure 1.5	Generalized stratigraphy and play element of central Indus basin	14
Figure 2.1	Petrophysical work flow chart	20
Figure 3.1	Interpreted well log of Pirkoh 01	27
Figure 3.1.1	Sandstone, shale and limestone in interpreted well log	27
Figure 3.2	Pickett plot for Pab interval in Pirkoh well 01	34
Figure 3.3	Representation of log curves with scales and colors	35
Figure 3.4	GR curve at depth 7320 feet with GRmin, GRmax and GRlog values	35
Figure 3.5	GR curve at depth 7400 feet with GRmin, GRmax and GRlog values.	36
Figure 3.6	Density log reading $\rho_b$ with $\rho_{ma and} \rho_{fl}$	36
Figure 3.7	Porosity and true formation Resistivity reading at depth 7500 feet	36
Figure 3.8	Water resistivity calculated at depth 7424 feet where LLS, LLD and MSFL meet	36
Figure 3.9	Porosity and true formation Resistivity reading at depth 7510 Feet to calculate	37
Figure 3.10	Porosity Vs Depth Cross Plot for Pirkoh-01	37
Figure 3.11	Sonic Vs Density Cross Plot for Pirkoh-01	38

Figure 3.12	Neutron porosity vs. density cross plot for Pirkoh-01	39
Figure 3.13	Shale Volume Vs density cross plot for Pirkoh-01	40
Figure 3.14	Resistivity Vs shale volume cross plot for Pirkoh-01	
		41
Figure 3.15	Sonic vs. neutron porosity For Pirkoh 01	42
Figure 3.16	Sand - Shale analysis for well Pirkoh 01 including	
	one major formation, Pab Sandstone	44
Figure 3.17	Graph between Sh and depth of Pirkoh 03	46
Figure 3.18	Graph between Sw and depth of Pirkoh 03	46
Figure 3.19	Graph between PHIA and depth of Pirkoh 03	46
Figure 3.20	Graph between PHIE and depth of Pirkoh 03	47
Figure 3.21	Graph between GR and depth of Pirkoh 03	47
Figure 3.22	Graph between Vsh and depth of Pirkoh 03	47

# Tables

Table 1.1	Well data detail with other related parameters	3
Table 3.1	Well Zonation for Pirkoh-01	28
Table 3.2	Typical Density Values For Some Common Types Of Matrixes	31