

**PETROPHYSICAL ANALYSIS OF BAHAWALPUR
EAST-01 WELL USING WIRELINE LOGS**



Khalid Nazir

Muhammad Naeem

**DEPARTMENT OF EARTH & ENVIRONMENTAL SCIENCES
BAHRIA UNIVERSITY ISLAMABAD**

**DEDICATED
TO
OUR BELOVED PARENTS**

ACKNOWLEDGEMENT

We are richly grateful to the Allah almighty for his beneficence and mercy which reposed the confidence in us to get through this arduous effort of compiling our age long learning into this work of thesis and endowed us to be among of those who have successfully completed BS in Geology.

We are also grateful to the last Prophet, Muhammad (S.A.W) to endeavor us with right knowledge and paved the way for us towards success in this life as well as in the eternal world. Our sweet motherland worthy of mentioning to be accolade giving us grounds for study.

We must not forget our family and our friends who kept us in good spirits and provided an emotional equilibrium which lead us to an infatigable discovery not only for our literary capabilities but also for our resilience and diligence.

Technically, we are greatly indebted to the guiding influence of Dr. Muhammad Zafar, Mr. Muhammad Zahid and Mr. Saqib Mehmood who guided us step by step towards ultimate completion of this treatise.

ABSTRACT

The main purpose of the study is to evaluate hydrocarbon potential of a well named Bahawalpur East-01, Punjab Platform, Central Indus Basin, Pakistan. This has been achieved by using complete suite of wire line logs and available well data. This complete set of data is issued by Land Mark Resources, Pakistan with the prior permission of Directorate General of Petroleum Concessions, Pakistan. To complete the above mentioned task the all logs were correlated to mark the zone of interest i.e. reservoir zone. In our case the reservoir is lying in Salt Range Formation of Precambrian age. After the demarcation of reservoir (Salt Range Formation), this zone was then divided into sub zones according to the quick look interpretation.

These zones were evaluated for the hydrocarbon potential in detail using set of equations. The methodology adopted to accomplish this task includes; the measurements for the Shale volume by using Gamma Ray Log, Porosities by Density & Neutron Log, Resistivity of water by using R_{wa} method, Saturation of water in the zone of reservoir and Hydrocarbon saturation using Archie equation.

The results for the dissertation were then displayed in the form of excel sheets and graphs for the better approach towards the task. These all displayed results show that the Salt Range of Bahawalpur East # 01 is 100% water bearing and has no considerable amount of hydrocarbon.

ABBREVIATIONS

d_h	Borehole diameter
d_i	Average diameter of invaded zone
d_j	Average outer diameter
h	Bed thickness in meters
R_m	Resistivity of the mud
R_{mf}	Resistivity of the mud filtrates
R_{mc}	Resistivity of the mud cake
R_w	Resistivity of the formation water
R_{wa}	Apparent resistivity of the formation water
R_t	Resistivity of the formation (uncontaminated zone)
R_o	Resistivity of the formation when 100% water filled
R_{xo}	Resistivity of the flushed zone
S_{xo}	Water saturation in flushed zone or invaded zone
R_i	Resistivity of invaded zone
V_{sh}	Volume of shale
R_{mfeq}	Equivalent mud filtrate resistivity
R_{weq}	Equivalent formation water resistivity
S_w	Saturation of water
S_h	Saturation of hydrocarbon
\emptyset	Porosity

Contents

Dedication	ii
Acknowledgement	iii
Abstract	iv
Abbreviations	v
Chapter 1	1
Introduction to Study Area.....	1
1.1 Location and Access.....	1
1.2 Objectives Of Research.....	1
1.3 Data Acquired for Interpretation	1
1.4 Methodology	1
Chapter 2	3
Regional Geology and stratigraphy	3
2.1 Regional Geological Settings	3
2.1.1 Structural Pattern of Punjab Platform.....	4
2.2 Tectonics of Punjab Platform.....	5
2.3 Geology of Punjab Platform.....	6
2.4 Generalized Stratigraphy of Punjab Platform	7
2.4.1 Pre-Cambrian Stratigraphy	9
2.4.2 Cambrian Stratigraphy.....	9
2.4.3 Triassic/Jurassic Stratigraphy	9
2.4.4 Cretaceous Stratigraphy.....	9
2.4.5 Paleocene Stratigraphy	10
2.4.6 Eocene Stratigraphy.....	11
2.4.7 Pleistocene Stratigraphy	12
2.5 Petroleum Geology of the Area.....	12
2.5.1 Hydrocarbon Potential	12
2.5.2 Petroleum System	12
Chapter 3	14
Introduction to Wireline Logging	14
3.1 Creating Wireline Logs	14
3.2 Wireline Logging Tools and Environments	15

3.3 Borehole Conditions.....	16
3.4 Invasion	18
3.5 Logging Tools and Principles	19
3.5.1 The Gamma Ray Log	19
3.5.2 Neutron Log.....	22
3.5.3 Density Log	24
3.5.4 Resistivity Measurement	27
3.5.5 Sonic Log.....	28
Chapter 4.....	30
Petrophysical Analysis.....	30
4.1 Wireline Logs Interpretation Work Flow.....	30
4.2 Petrophysical Parameters & Interpretation Techniques.....	31
4.2.1 Volume of Shale	31
4.2.2 Porosity Calculation	32
4.2.3 Resistivity of Water	35
4.2.4 Water Saturation	36
4.2.5 Saturation of Hydrocarbons.....	365
4.2.6 Permeability	38
4.3 Petrophysical Interpretation	38
4.3.1 Interpretation of Wireline Logs of Bahawalpur East # 1.....	38
Conclusions and Recommendations.....	58
References.....	59
Appendices.....	61
Appendix I.....	61
Appendix II	60

LIST OF FIGURES

Figure 1.1. Map showing the Punjab Platform with Well Location (after Ahmed et al, 1984).....	2
Figure 2.1: Tectonic Settings of Punjab platform (Central Indus Basin) (Mahmud S. A. and Ahmed Shamim, 2009).....	4
Figure 2.2. Central Indus Basin and subdivision into petroleum zones (after Raza et al, 1989).....	5
Figure 2.3. Generalized Stratigraphic Column of Central Indus Basin, Punjab Platform (Courtesy OGDCL)	9
Figure-3.1. The Borehole Environment and Symbols Used in Log Interpretation (Introduction to Wireline Log Interpretation)	15
Figure 3.2. Graphical Representation of Gamma Ray Log (www.geomore.com)	19
Figure 3.3. Basic Sgt-Cnl-Ldt Tool Configuration (Schlumberger Drilling Services Catalog, 2001)	20
Figure 3.4. Basic Neutron Tool Configuration (Schlumberger Drilling Services Catalog, 2001).....	22
Figure 3.5. A Schematic Drawing of Formation Density Logging Device (Schlumberger Drilling Services Catalog, 2001).....	24
Figure 3.6. Laterolog tool assembly. The sensors include ring & bit resistivity and three azimuthally oriented electrodes for imaging capabilities with downhole processing (Schlumberger Drilling Services Catalog, 2001)	26
Figure 3.7. Schematic Diagram, Showing Ray Paths (Schlumberger Drilling Services Catalog, 2001)	27
Figure-4.1: Flow chart	29

LIST OF GRAPHS

Graph 4.1. Depth versus shale volume variation	32
Graph 4.2. Depth versus average porosity variation.....	34
Graph 4.3. Depth versus effective porosity variation.....	36
Graph 4.4. Depth versus Water saturation variation	37
Graph 4.5. Hydrocarbon saturation variation with depth	36
Graph 4.6 Depth Vs VShale, PHIE, S_w , & S_h (Zone 1).....	37
Graph 4.7 Depth Vs VShale, PHIE, S_w , & S_h (Zone 2).....	37
Graph 4.8 Depth Vs VShale, PHIE, S_w , & S_h (Zone 3).....	38
Graph 4.9 Depth Vs VShale, PHIE, S_w , & S_h (Zone 4).....	38
Graph 4.10 Depth Vs VShale, PHIE, S_w , & S_h (Zone 5).....	39
Graph 4.11 Depth Vs VShale, PHIE, S_w , & S_h (Zone 6).....	39
Graph 4.12 Depth Vs VShale, PHIE, S_w , & S_h (Zone 7).....	40
Graph 4.13 Depth Vs VShale, PHIE, S_w , & S_h (Zone 8).....	40
Graph 4.14 Depth Vs VShale, PHIE, S_w , & S_h (Zone 9).....	41
Graph 4.15 Depth Vs VShale, PHIE, S_w , & S_h (Zone 10).....	41
Graph 4.16 Depth Vs VShale, PHIE, S_w , & S_h (Zone 11).....	42
Graph 4.17 Depth Vs VShale, PHIE, S_w , & S_h (Zone 12).....	42
Graph 4.18 Depth Vs VShale, PHIE, S_w , & S_h (Zone 13).....	43
Graph 4.19 Depth Vs VShale, PHIE, S_w , & S_h (Zone 14).....	43
Graph 4.20 Depth Vs VShale, PHIE, S_w , & S_h (Zone 15).....	44
Graph 4.21 Depth Vs VShale, PHIE, S_w , & S_h (Zone 16).....	44
Graph 4.22 Depth Vs VShale, PHIE, S_w , & S_h (Zone 17).....	45
Graph 4.23 Depth Vs VShale, PHIE, S_w , & S_h (Zone 18).....	45
Graph 4.24 Depth Vs VShale, PHIE, S_w , & S_h (Zone 19).....	46
Graph 4.25 Depth Vs VShale, PHIE, S_w , & S_h (Zone 20).....	46
Graph 4.26 Depth Vs VShale, PHIE, S_w , & S_h (Zone 21).....	47
Graph 4.27 Depth Vs VShale, PHIE, S_w , & S_h (Zone 22).....	47
Graph 4.28 Depth Vs VShale, PHIE, S_w , & S_h (Zone 23).....	48
Graph 4.29 Depth Vs VShale, PHIE, S_w , & S_h (Zone 24).....	48
Graph 4.30 Depth Vs VShale, PHIE, S_w , & S_h (Zone 25).....	49
Graph 4.31 Depth Vs VShale, PHIE, S_w , & S_h (Zone 26).....	49
Graph 4.32 Depth Vs VShale, PHIE, S_w , & S_h (Zone 27).....	50

Graph 4.33 Depth Vs VShale, PHIE, S_w , & S_h (Zone 28).....	50
Graph 4.34 Depth Vs VShale, PHIE, S_w , & S_h (Zone 29).....	51
Graph 4.35 Depth Vs VShale, PHIE, S_w , & S_h (Zone 30).....	51
Graph 4.36 Depth Vs VShale, PHIE, S_w , & S_h (Zone 31).....	52
Graph 4.37 Depth Vs VShale, PHIE, S_w , & S_h (Zone 32).....	52
Graph 4.38 Depth Vs VShale, PHIE, S_w , & S_h (Zone 33).....	53
Graph 4.39 Depth Vs VShale, PHIE, S_w , & S_h (Zone 34).....	53
Graph 4.40 Depth Vs VShale, PHIE, S_w , & S_h (Zone 35).....	54
Graph 4.41 Depth Vs VShale, PHIE, S_w , & S_h (Zone 36).....	54
Graph 4.42 Depth Vs VShale, PHIE, S_w , & S_h (Zone 37).....	55
Graph 4.43 Depth Vs VShale, PHIE, S_w , & S_h (Zone 38).....	55