

**STRUCTURAL AND PETROPHYSICAL ANALYSIS OF
MINWAL AREA, UPPER INDUS BASIN, PAKISTAN**



BY

KHADIJA ATHAR

MIFRAH AFTAB

ZONA UMAIR

**Department of Earth and Environmental Sciences
Bahria University, Islamabad**

2016

STRUCTURAL AND PETROPHYSICAL ANALYSIS OF MINWAL AREA, UPPER INDUS BASIN, PAKISTAN



A thesis submitted to Bahria University, Islamabad in partial fulfillment of the requirement for the degree of BS in Geophysics

KHADIJA ATHAR

MIFRAH AFTAB

ZONA UMAIR

Department of Earth and Environmental Sciences

Bahria University, Islamabad

2016

ACKNOWLEDGEMENTS

All praise to Allah, the beneficent, the merciful.

We would like to express our gratitude to our supervisor Professor Mohammad Fahad Mahmood, who offered invaluable assistance, support and guidance. Without his wisdom and his patience to guide us through this challenge, this thesis would not have been possible.

Deepest gratitude is also due to Dr Tahseenullah Khan, Dr Muhammad Zafar and Professor Saqib Mehmood for sharing their knowledge and experience and aiding us throughout this challenging journey.

ABSTRACT

Minwal area is located 105kms southwest of Islamabad, in Chakwal district. Geographically, the study area lies between 33°2'51"N and 72°51'16"E. Geologically, the oilfield is situated in southeast of Salt Range, Upper Indus Basin, which is characterized by number of thrust faults and reverse faults, producing anticlines and synclines. The research highlights the 2D structural interpretation and well logs integration in order to reveal the structure of the area and hydrocarbon prospect. TWT, velocity and depth contour maps generated show a triangle zone in the area, bounded by two thrust faults. Petroleum play in the area reveals that Patala Formation of Paleocene is acting as a source rock; Chorgali Formation and Sakesar Limestone of Eocene is acting as a reservoir and Murree Formation of Miocene is acting as a seal. A synthetic seismogram has also been generated using the concept of forward modeling, of the location. Mainly, the zone of interest in well log interpretation lies in Sakesar Formation, in which, three zones have been marked. Log analysis of these three zones shows that the zone 1 of Sakesar limestone is more promising for hydrocarbon potential. Work is concluded by reserve estimation through volumetric method. Reserve Estimation further also confirms that the zone 1 has more hydrocarbon potential as compared to the two other zones.

CONTENTS

	Page
Acknowledgements	i
Abstract	ii
Figures	viii
Tables	x

Chapter 1

Introduction

1.1	Introduction to the study area	1
1.2	Location of the study Area	1
1.3	Objectives of the research	2
1.4	Methodology of Research	3
1.5	Available Data	3
	1.5.1 Seismic Lines	4
	1.5.2 Well data	4
1.6	Well Tops	5
1.7	Base Map	5

Chapter 2

Geology And Tectonics

2.1	General Geology	6
	2.1.1 Potwar Plateau	6
	2.1.2 Kalabagh Fault	8
	2.1.3 Jhelum Fault	8
	2.1.4 Salt Range Thrust	8
	2.1.5 Main Boundary Thrust (MBT)	8

Chapter 3

Stratigraphy And Petroleum Play

3.1	Formations Encountered In Study Area	11
3.1.1	Nagri Formation	11
3.1.2	Chinji Formation	11
3.1.3	Kamlial Formation	11
3.1.4	Murree Formation	12
3.1.5	Chorgali Formation	12
3.1.6	Sakesar Formation	12
3.1.7	Lockhart Formation	12
3.1.8	Khewra Sandstone	12
3.2	Petroleum Play	13
3.2.1	Hydrocarbon Potential	13
3.2.2	Source Rocks	13
3.2.3	Reservoir Rocks	13
3.2.4	Cap Rocks	13
3.2.5	Traps	14

Chapter 4

Seismic Data Acquisition And Processing

4.1	Seismic Data Acquisition	16
4.2	Acquisition Parameters	16
4.2.1	Source Parameters	16
4.2.2	Receiver Parameters	17
4.2.3	Recording Parameters	17
4.3	Seismic Data Processing	18

Chapter 5

Synthetic Seismogram

20

Chapter 6
Seismic Data Interpretation

6.1	Introduction	22
6.2	Seismic Interpretation Approaches	22
6.2.1	Stratigraphic Analysis	22
6.2.2	Structural Analysis	23
6.3	Flowchart for seismic Interpretation	23
6.4	Selection of Control Line	24
6.5	Velocity Analysis	24
6.6	Time Depth Chart (TD-Chart)	24
6.7	Marking of Reflectors	25
6.8	Correlation of Reflectors	26
6.9	Faults Marking	26
6.10	Time Picking and TWT Contour Map	29
6.10.1	Two Way Time Contour Map (TWT) of Chorgali Formation	30
6.10.2	TWT Contour Map of Sakesar Formation	31
6.10.3	TWT Contour Map of Lockhart Formation	32
6.10.4	TWT Contour Map of Khewra Formation	33
6.11	Velocity Contour Map	34
6.11.1	Velocity Contour Map of Chorgali Formation	34
6.11.2	Velocity Contour Map of Sakesar Formation	35
6.11.3	Velocity Contour Map of Lockhart Formation	36
6.11.4	Velocity Contour Map of Khewra Formation	37
6.12	Depth Contour Map	38
6.12.1	Depth Contour Map of Chorgali Formation	38
6.12.2	Depth Contour Map of Sakesar Formation	39
6.12.3	Depth Contour Map of Lockhart Formation	40
6.12.4	Depth Contour Map of Khewra Formation	41

Chapter 7
Petrophysical Evaluation

7.1	Well Data	42
7.2	Flowchart for Petro-physical Interpretation	43
7.3	Marking Zone of Interest	43
7.4.	Calculation of Volume of Shale (Vsh)	48
7.5	Calculation of Vclean or Volume of limestone	48
7.6	Calculation of Density Porosity (PHID)	48
7.7	Calculation of Neutron Porosity (PHIN)	49
7.8	Calculation of Average Porosity (PHIA) and Effective Porosity (PHIE)	49
7.9	Calculation of Resistivity of water (Rw) for the particular formation	49
7.10	Calculation of Saturation of water (Sw) and Saturation of Hydrocarbon (Vsh)	50
7.11	Petro-physical Interpretation of Zone 1	51
	7.11.1 Volume of shale Curve of Zone 1	53
	7.11.2 Density and Neutron Porosity Curve of Zone 1	54
	7.11.3 Average Porosity and Effective Porosity Curve of Zone 1	55
	7.11.4 Saturation of Water and Hydrocarbon Curve of Zone 1	56
7.12	Petrophysical Interpretation of Zone 2	57
	7.12.1 Volume of shale Curve of Zone 2	58
	7.12.2 Density and Neutron Porosity Curve of Zone 2	59
	7.12.3 Average Porosity and Effective Porosity Curve of Zone 2	60
	7.12.4 Saturation of Water and Hydrocarbon Curve of Zone 2	61
7.13	Petrophysical Interpretation of Zone 3	62
	7.13.1 Volume of shale Curve of Zone 3	63
	7.13.2 Density and Neutron Porosity Curve of Zone 3	64
	7.13.3 Average Porosity and Effective Porosity Curve of Zone 3	65
	7.13.4 Saturation of Water and Hydrocarbon Curve of Zone 3	66

Chapter 8

Reserve Estimation

8.1	Volumetric Analysis	67
	Conclusions	69
	References	70

FIGURES

		Page
Figure 1.1	Location of the study area	2
Figure 1.2	Base map of study area	5
Figure 2.1	Geology and tectonics of the study area	7
Figure 3.1	Stratigraphic map and petroleum play of Upper Indus Basin	10
Figure 4.1	Seismic acquisition	15
Figure 5.1	Process of Generation of Synthetic Seismogram	20
Figure 5.2	Synthetic Seismogram of Minwal-X1	21
Figure 6.1	Time- Depth Chart	25
Figure 6.2	Seismic Section of SPOL-93-MN-04	27
Figure 6.3	Seismic Section of SPOL-93-MN-05	27
Figure 6.4	Seismic Section of SPOL-93-MN-06	28
Figure 6.5	Seismic Section of SPOL-93-MN-08	28
Figure 6.6	Seismic Section of SPOL-93-MN-11	29
Figure 6.7	Time Contour Map of Chorgali Formation	30
Figure 6.8	Time Contour Map of Sakesar Formation	31
Figure 6.9	Time Contour Map of Lockhart Formation	32
Figure 6.10	Time Contour Map of Khewra Formation	33
Figure 6.11	Velocity Contour Map of Chorgali Formation	34
Figure 6.12	Velocity contour Map of Sakesar Formation	35
Figure 6.13	Velocity contour Map of Lockhart Formation	36
Figure 6.14	Velocity contour Map of Khewra Formation	37
Figure 6.15	Depth contour Map of Chorgali Formation	38
Figure 6.16	Depth contour Map of Sakesar Formation	39
Figure 6.17	Depth contour Map of Lockhart Formation	40
Figure 6.18	Depth contour Map of Khewra Formation	41
Figure 7.1	First Zone of Interest	45
Figure 7.2	Second Zone of Interest	46
Figure 7.3	Third Zone of Interest	47

Figure 7.4	Shale Volume in reservoir zone 1	53
Figure 7.5	Neutron Porosity and Density Porosity in reservoir zone 1	54
Figure 7.6	Average Porosity and Effective Porosity in reservoir zone 1	55
Figure 7.7	Water Saturation and Hydrocarbon Saturation in reservoir zone 1	56
Figure 7.8	Shale Volume in reservoir zone 2	58
Figure 7.9	Density Porosity and Neutron Porosity in reservoir zone 2	59
Figure 7.10	Average Porosity and Effective Porosity in reservoir zone 2	60
Figure 7.11	Water Saturation and Hydrocarbon Saturation in reservoir zone 2	61
Figure 7.12	Shale Volume in reservoir zone 3	63
Figure 7.13	Density and Neutron Porosity in reservoir zone 3	64
Figure 7.14	Average Porosity and Effective Porosity in reservoir zone 3	65
Figure 7.15	Water Saturation and Hydrocarbon Saturation in reservoir zone 3	66

TABLES

	Page	
Table 1.1	Well tops of Minwal X-01	4
Table 4.1	Source parameters of the study area.	16
Table 4.2	Receiver parameters of study area	17
Table 4.3	Recording Parameters	17
Table 7.1	Well Data of Minwal X-01	42
Table 7.2	First zone of interest	44
Table 7.3	Second zone of interest	44
Table 7.4	Third zone of interest	44
Table 7.5	Interpretation results of zone 1	51
Table 7.6	Interpretation results of zone 2	57
Table 7.7	Interpretation results of zone 3	62
Table 8.1	Results of Volumetric Analysis	68