

**RESERVOIR CHARACTERIZATION OF SAWAN GAS
FIELD, MIDDLE INDUS BASIN, PAKISTAN**



By

HINAN AHMAD

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

2010

**Reservoir characterization of Sawan gas field, middle Indus
basin, Pakistan**



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

Hinan Ahmad

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

2010

ACKNOWLEDGMENTS

I am grateful to my supervisor Ms. Mehwish Butt, Lecturer, Bahria University, Islamabad, for her endless support and encouragement during this study. Her suggestions and help were integral to the timely completion of this study. I would like to pay special thanks to my co-supervisor Mr. Abdul Hamid, Geophysicist, OGDCL, for his kind supervision, valuable and expert guidance and inspiration bring this research to success. Dr. M. Mujtaba, former Chief Geologist, HDIP, and Mr. Fahad Arif, Senior Petrohysicist, Schlumberger Pakistan, are thanked for providing me with their support. I gratefully acknowledge the guidance and resources provided by Dr. Muhammad Zafar, Head of Department, Earth and Environmental Sciences, Bahria University, Islamabad. I am also thankful to Prof. Dr Tahseenullah Khan, Department of Earth and Environmental Sciences, Bahria University, Islamabad, for critically viewing this thesis.

I would also like to express my heartiest and special gratitude to all my respected and honorable teachers of the department of Earth and Environmental Sciences, Bahria University, Islamabad. I may express heartfelt thanks to all my friends especially to Mr. Abdul Qayyum for his help in understanding the basics of Geographix software.

ABSTRACT

Sawan Field is located in the Thar Desert, District Khairpur in Sindh province of Pakistan. The study area lies in the extensional tectonic regime exhibiting horst and graben structure. Lower Goru Formation is acting as a potential reservoir which is being charged by shale of Sembar Formation. In the present study hydrocarbon potential of Sawan Field has been interpreted by evaluating the well logs of one exploratory well (Sawan-03B) and two development wells (Sawan-07 and Sawan-08) in terms of reservoir characterization. The petrophysical properties which have been determined include clay volume, effective porosity, permeability, saturation of water and hydrocarbon. Lithology and clay mineral identification have been done with the help of cross plots and charts. Low Resistivity Pay (LRP) phenomenon has been observed in reservoir zone and suitable reasoning is proposed to deal with it. Finally, depositional environments of reservoir facies have been determined by identifying a number of sequences on GR log curve and these facies are then correlated. It has been determined that main lithology of the reservoir is sandstone with intercalations shale containing illite abundantly. The values of Resistivity logs are relatively low ranging 3-15 ohm-m in the hydrocarbon zone because of the Low Resistivity Pay Phenomenon. With the help of facies analysis it has been interpreted that the depositional environment of reservoir facies is shallow marine to deep marine and there is a considerable change in the depth of these facies from north to south in the study area. On the basis of all these delineated petrophysical parameters it has been determined that Sawan Field has great potential to produce commercially viable natural gas.

CONTENTS

ABSTRACT	i
ACKNOWLEDGMENTS	
iii	
CONTENTS	iii
FIGURES	iii
TABLES	ix

CHAPTER 1

INTRODUCTION

1.1	Exploration History of Middle Indus Basin	1
1.2	Sawan gas Field	3
1.3	Previous Work	4
1.4	Objective of the Present Study	6
1.5	Data acquired	6

CHAPTER 2

REGIONAL GEOLOGY

2.1	Basin Configuration and Tectonics Settings	7
2.2	General Stratigraphy of Middle Indus Basin	10
2.3	Stratigraphy of the Study Area	11
2.3.1	Cretaceous Stratigraphy	11
2.3.2	Paleogene Stratigraphy	11
2.3.3	Neogene and Quaternary Stratigraphy	12

CHAPTER 3

FORMATION EVALUATION

3.1	Introduction	14
3.2	Methodology	14
3.2.1	Marking Zone of Interest	15
3.2.2	Calculation of Volume of Shale (Vshl)	15
3.2.3	Porosity Calculation	16
3.2.3.1	Neutron Porosity	16
3.2.3.2	Density Porosity	16
3.2.3.3	Average Neutron Density Porosity	16
3.2.3.4	Effective Porosity	17
3.2.4	Saturation of Formation	17
3.2.4.1	Water Saturation	18
3.2.4.2	Determination of R_w	18
3.2.4.3	Hydrocarbon Saturation	19
3.2.5	Permeability	19
3.2.6	Net Pay	19
3.2.7	Determination of Lithology	19
3.2.8	Identification of Minerals	20

CHAPTER 4

PETROPHYSICAL INTERPRETATION

4.1	Interpretation of Sawan-03B	21
4.1.1	Interpretation of Zone-1	21
4.1.2	Interpretation of Zone-2	25
4.2	Interpretation of Sawan-07	29
4.3	Interpretation of Sawan-08	33

CHAPTER 5

LITHOLOGY AND MINERALS IDENTIFICATION

5.1	Lithology Determination	37
5.2	Minerals Identification	39
5.3	Low Resistivity Pay	40

CHAPTER 6

DEPOSITIONAL ENVIRONMENT

6.1	Introduction	43
6.2	Interpretation of depositional environment	43
6.2.1	Funnel shape	43
6.2.2	Bell shape	44
6.2.3	Cylindrical shape	44
6.2.4	Bow trend	44
6.2.5	Irregular trend	45
6.3	Depositional environment of Sawan-03B	45
6.3.1	3650 – 3600 meter	45
6.3.2	3600 – 3576 meter	45
6.3.3	3576 – 3460 meter	45
6.3.4	3460 – 3329 meter	46
6.4	Depositional environment of Sawan-08	46
6.4.1	3390 – 3358 meter	46
6.4.2	3358 – 3237 meter	46
6.5	Depositional environment of Sawan-07	47
6.5.1	3390 – 3354 meter	47
6.5.2	3354 – 3221 meter	47
	CONCLUSIONS	48
	RECOMENDATIONS	50
	REFERENCES	51
	APPENDICES	53

Appendix A	53
Appendix B	54
Appendix C	55
Appendix D	56

FIGURES

Figure 1.1.	Location of the study area	2
Figure 1.2.	A short history of petroleum discoveries in Pakistan	3
Figure 1.3.	Well distribution in Sawan field	6
Figure 2.1.	Basin configuration of study area	9
Figure 2.2.	Tectonic settings of southern Indus basin	9
Figure 3.1	Work flow of petrophysical interpretation	15
Figure 3.2.	Baker Atlas cross-plot for lithology identification	20
Figure.3.3.	Schlumberger cross-plot for mineral identification	20
Figure 4.1.	Shale volume against depth in Sawan-03B (zone-1)	21
Figure 4.2.	Effective porosity against depth in Sawan-03B (zone-1)	22
Figure 4.3.	Saturation of water against depth in Sawan-03B (zone-1)	22
Figure 4.4.	Saturation of hydrocarbons against depth in Sawan-03B (zone-1)	23
Figure 4.5.	Timur permeability against depth in Sawan-03B (zone-1)	23
Figure 4.6.	Log curves response in Sawan-03B (zone-1)	24
Figure 4.7.	Volume of shale against depth in Sawan-03B (zone-2)	25
Figure 4.8.	Effective porosity against depth in Sawan-03B (zone-2)	26
Figure 4.9.	Saturation of water against depth in Sawan-03B (zone-2)	26
Figure 4.10.	Saturation of hydrocarbons against depth in Sawan-03B (zone-2)	27
Figure 4.11.	Timur permeability against depth in Sawan-03B (zone-2)	27
Figure 4.12.	Log curve response in Sawan-03B (zone-2)	28
Figure 4.13.	Volume of shale against depth in Sawan-07	29
Figure 4.14.	Effective porosity against depth in Sawan-07	30
Figure 4.15.	Saturation of water against depth in Sawan-07	30
Figure 4.16.	Saturation of hydrocarbons against depth in Sawan-07	31
Figure 4.17.	Permeability against depth in Sawan-07	31
Figure 4.18.	Log curve response in Sawan-07	32
Figure 4.19.	Volume of shale against depth in Sawan-08	33
Figure 4.20.	Effective porosity against depth in Sawan-08	34
Figure 4.21.	Saturation of water against depth in Sawan-08	34
Figure 4.22.	Saturation of hydrocarbons against depth in Sawan-08	35
Figure 4.23.	Timur permeability against depth in Sawan-08	35
Figure 4.24.	Log curves response in Sawan-08	36

Figure 5.1.	Lithology cross plot of Sawan-03B (1)	37
Figure 5.2.	Lithology cross plot of Sawan-03B (2)	38
Figure 5.3.	Lithology cross plot of Sawan-07	38
Figure 5.4.	Lithology cross plot of Sawan-08	39
Figure 5.5.	Identification of minerals in Sawan-08 well	40
Figure 5.6.	Low resistivity pay zone in Sawan-07 well	42
Figure 6.1.	Trends of GR log in different depositional environments	44

TABLES

Table 2.1. Generalized stratigraphy of the Middle Indus Basin	10
Table 2.2. Stratigraphic sequence of the study area	13