

**EVIDENCE OF WRENCH TECTONICS IN
EASTERN POTWAR, PAKISTAN AND ITS
IMPLICATION ON HYDROCARBON
PROSPECTS**



By

Fatima Afsar

Faculty of Earth and Environmental Sciences
Bahria University, Islamabad
2007

CONTENTS

<u>Sr. No.</u>		<u>Page No.</u>
	ACKNOWLEDGEMENT	X
	ABSRTRACT	XI
1.	Introduction	1
2.	Database	6
	2.1. Methodology and Organization	6
3.	Regional Tectonic Setting	7
4.	Stratigraphy of Eastern Potwar	18
	4.1. Infra-Cambrian	23
	4.1.1. Jodhpur Formation	23
	4.1.2. Bilara Formation	23
	4.1.3. Salt Range Formation	25
	4.2. Paleozoic	26
	4.2.1. Cambrian	26
	4.2.2. Khewra Sandstone	26
	4.2.3. Kussak Formation	26
	4.2.4. Jutana Formation	27
	4.2.5. Baghanwala Formation	27
	4.3. Permian	28
	4.3.1. Nilawahan Group	28
	4.3.2. Tobra Formation	28
	4.3.3. Dandot Formation	29
	4.3.4. Warchha Sandstone	29
	4.3.5. Sardhai Formation	30
	4.3.6. Zaluch Group	30
	4.3.7. Amb Formation	30
	4.4. Cenozoic	31
	4.5. Paleocene	31
	4.5.1. Hangu Formation	31
	4.5.2. Lockhart Limestone	32
	4.5.3. Patala Formation	32
	4.6. Eocene	33
	4.6.1. Nammal Formation	33
	4.6.2. Sakesar Limestone	33
	4.6.3. Chorgali/Badhrar Formation	34
	4.7. Oligocene	34
	4.8. Miocene-Pleistocene	34
	4.9. Rawalpindi Group	35
	4.9.1. Murree Formation	35
	4.9.2. Kamlial Formation	35
	4.10. Siwalik Group	36

4.10.1.	Chinji Formation	36
4.10.2.	Nagri Formation	37
4.10.3.	Dhok Pathan Formation	38
4.10.4.	Soan Formation	38
5.	Significance of Tectonic Environment in the Development of Structural / Stratigraphic traps	40
6.	Tectonics and Structural Styles of Potwar Sub-basin – A Brief Description of the Previous Work.	47
7.	Tectonic Environment and Structural Style of Eastern Potwar	58
7.1.	Review and Selection of Data	58
7.2.	Seismic Interpretation Procedure	60
7.3.	Structural Styles and Hydrocarbon Traps	63
7.3.1.	Chak Beli Khan Anticline	63
7.3.2.	Tanwin-Bains Anticline	63
7.3.3.	Adhi Anticline	64
7.3.4.	Bhubar anticline	64
7.3.5.	Qazian Anticline	65
7.3.6.	Mahesian Anticline	65
7.3.7.	Rohtas Anticline	65
7.3.8.	Jodhpur-Bilara Prospects	66
8.	Source Rock	67
8.1.	Parameters for the evaluation of source rocks used in the study	67
8.1.1.	Organic Richness (TOC)	67
8.1.2.	Extractable Organic Matter (EOM)	68
8.1.3.	General Range of EOM (PPM)	68
8.1.4.	Genetic Potential (GP)	68
8.1.5.	Hydrocarbon Index (HI: mg of hydrocarbons/g of TOC)	68
8.1.6.	General Range of Hydrocarbon index (HI)	69
8.2.	Source rock characteristics in eastern Potwar	69
8.2.1.	Bilara Formation	69
8.2.2.	Salt Range Formation	69
8.2.3.	Amb Formation	69
8.2.4.	Patala Formation	70
9.	Reservoir Quality	71
9.1.	Producing Reservoirs of Potwar Sub-basin	71
9.1.1.	Producing reservoirs of eastern Potwar	71
9.1.2.	Probable reservoirs of eastern Potwar	72
9.2.	Reservoir Characteristics of Producing and Probable Horizons of Eastern Potwar	72
9.2.1.	Jodhpur Formation (Probable Reservoir)	72
9.2.2.	Bilara Formation (Probable Reservoir)	75
9.2.3.	Salt Range Formation (Probable Reservoir)	75
9.2.4.	Khewra Formation (Producing Reservoir)	76
9.2.5.	Kussak Formation (Probable reservoir)	76
9.2.6.	Jutana Formation (Producing Reservoir)	78
9.2.7.	Tobra Formation (Producing Reservoir)	78

9.2.8.	Amb Formation (Producing Reservoir)	78
9.2.9.	Hangu Formation (Producing Reservoir)	78
9.2.10.	Lockhart Formation (Producing Reservoir)	78
9.2.11.	Sakesar Formation (Producing Reservoir)	79
9.2.12.	Chorgali/Badhrar Formation (Producing Reservoir)	79
10.	Hydrocarbon Generation Migration and Accumulation	80
11.	Producing Examples	83
12.	Conclusions and Recommendations	88
13.	References	90

TABLES

Table 1:	Generalized Stratigraphic column of Eastern Potwar.	20
Table 2:	Producing Reservoirs of Eastern Potwar	73
Table 3:	Probable Source-Reservoir-Seal Trilogy, Mechanics of Migration and Hydrocarbon traps.	81

FIGURES

Figure 1:	Map showing sedimentary basins of Pakistan and location of study area	2
Figure 2:	Map showing structural elements in Potwar sub-basin, Pakistan.	3
Figure 3:	Well location map of Potwar sub-basin and part of Kohat sub-basin.	5
Figure 4:	Seismic section through well Baghewal-1 of Bikaner-Nagaur Basin, India showing Unconformities, Rift features of Infra-Cambrian, Permian, Mesozoic and Probable Permo-Triassic Reef	9
Figure 5:	Seismic section showing rift features of Infra-Cambrian and Permian time in Punjab Platform.	10
Figure 6:	Conceptual play type of Infra-Cambrian in Bikaner-Nagaur Basin and Punjab Platform	11
Figure 7:	Correlation of wells indicating Onlaps of Bilara and Jodhpur formations of Infra-Cambrian age on Paleo-high of Kalrewala-1.	12
Figure 8:	Seismic section in Sindh Platform showing normal faults developed as a consequence of Cretaceous rifting.	14
Figure 9:	Regional tectonic map, showing the location of Pakistan on the northwestern corner of the Indian Plate and regional tectonic features in the area.	15
Figure 10:	Generalized tectonic map of Pakistan showing two large basins of Pakistan; Indus and Balochistan basin separated by Bela-Ornach-Chaman Fault.	16
Figure 11:	Map showing truncated limits of Early Permian-Cretaceous strata, well locations and producing fields of Potwar sub-basin.	21
Figure 12:	East-West schematic cross-section of Potwar sub-basin portraying the generalized stratigraphy hydrocarbon occurrence and	22

ABSTRACT

The Hydrocarbon prospects of Eastern Potwar, Pakistan are assessed on the basis of a new structural and tectonic concept utilizing geological, geophysical, geochemical, petrophysical and other relevant geoscientific data. So far it is considered that the structural styles in Potwar sub-basin are the result of compressional thin-skinned tectonics. According to our interpretation of geological and geophysical data, the structural patterns in eastern Potwar have been developed as a consequence of transpressional wrench movements initiated during late Tertiary time along Murree-Jhelum strike-slip fault. The study further indicate that the normal faults in the region are the results of Infra-Cambrian rifting and not the product of flexural loading of the basement due to southwards advancing thrust sheets as interpreted by previous workers. Thus oil and gas pools are associated with positive flower structures, sub-thrust plays, reverse and normal faults. The producing clastic and carbonate reservoir facies of Infra-Cambrian age in Bikaner-Nagaur basin of India have also been identified in the study area. The traps associated with wrench tectonics and rifting in other parts of the world have produced hydrocarbons in commercial quantities. Therefore the area deserves exploration with revised targets and in the background of new play concepts.