SOURCE ROCK EVALUATION OF DATTA SHALE, KOHAT SUB-BASIN, PAKISTAN

By

ADEEB AHMED

Department of Earth and Environmental Sciences

Bahria University, Islamabad

2016

ABSTRACT

The Kohat sub-basin, a northwest extension of the Indus basin in KPK, is the main hydrocarbon producing basin of the province. Despite the fact that the first hydrocarbon discovery was made in the adjacent Potwar sub-basin in 1915, the discovery of hydrocarbon in the Kohat sub-basin is relatively recent and started with a breakthrough discovery from Chanda-01 by Oil and Gas Development Company Limited in 1999. Following this discovery, around 10 hydrocarbon fields have been discovered in the Kohat sub-basin since then.

Jurassic Datta Formation is producing liquid hydrocarbons in the Kohat area. Datta sandstone is acting as a reservoir. However, little is known about the source potential of Datta shale. The potential to generate hydrocarbons is function of the organic matter type, quantity of preserved matter and its thermal maturity. Outcrop samples from Chichali gorge and well cuttings of Chanda field, and oil samples from Chanda wells were analyzed for geochemical characteristics to understand the organic matter source, environment of deposition, thermal maturity, and probable type of hydrocarbon generation and correlation of Datta source characteristics with crude oil to establish oil-source correlation.

The quantification of organic content of Datta shale indicates variation in organic richness. The well cuttings of Datta shale falls in the category of good to very good source rock. The variation in organic richness in comparison to outcrop samples of Chichali gorge reflects facies variation. The qualitative assessment of Datta shale by Rock Eval pyrolysis indicates thermal maturity, hydrocarbon potential. With reference to generated hydrocarbons (S1) and remaining potential (S2), Datta shale ranked as fair to good source rock. Datta shale mainly comprises marine organic matter, Type-II with some terrestrial input in few cases. Type-II organic matter is oil/gas prone whilst type-III is gas prone. In case of outcrop samples very low values of hydrogen index result from weathering, oxidation of organic matter. RE shows maturity of the samples in peak oil generation phase. It is supplemented by VR values.

The crude oil samples and Datta source rock extract show higher abundance of saturated hydrocarbons, being > 40%. The relative ratio of fractions; saturate HCs: aromatic HCs: NSO compounds show good correlation of Chanda oil to Datta shale. There is no odd to even predominance or bimodal distribution for oil and extracts

saturated hydrocarbon fingerprinting. OEP and CPI values of rock extract and oil are close to one, indicating comparable maturity. However, Datta shale extracts show higher concentration of higher n-alkanes compared to Chanda oil.

Isoprenoid/n-alkane ratio indicates the mixed organic matter input for Chanda oil while Datta shale has predominant marine organic matter. Both, the oil and extract show higher bacterial source contribution than algal as terpane biomarkers fingerprint is dominated by hopanes with low relative abundance of tricyclic terpanes reflected. Higher relative abundance of C_{29} sterane indicates terrestrial influence with marine input.

Sterane maturity parameter, S/S+R of crude oils from Chanda field reflects its source rock has attained equilibrium for isomers and values of these parameters are comparable to those from Datta shale. ββ/ββ+αα values indicate the source of Chanda oil and Datta shale has attained peak oil generation phase.

Oleanane biomarker is source and age indicator, it has origin in land plants, angiosperms evolving from Late Cretaceous and early Tertiary period. Oleanane index values for oil and source rock extract demonstrate Jurassic-Cretaceous age.

The stable carbon isotope of Datta shale and Chanda oils show positive oil-source correlation.

ACKNOWLEDGEMENTS

First of all I am thankful to Almighty Allah who gave me power and strength to do the thesis and countless salutation upon Holy Prophet Muhammad (S.A.A.W), the origin of knowledge who has guided his (Ummah) to seek information from cradle to grave.

I wish to express my deepest gratitude for research supervisor, Mr. Saqib Mehmood, Assistant Professor, Department of Earth and Environmental Sciences, Bahria University Islamabad and co-supervisor, Dr. Samina Jahandad, Senior Chemist, Hydrocarbon Development Institute of Pakistan (HDIP) whose encouragement, advice and cooperative attitude enabled me to overcome the difficulties that I came across. I took full advantage of their knowledge and inspiring attitude.

My deepest appreciation is to my Head of Department Prof. Dr. Muhammad Zafar, Earth and Environmental Sciences Islamabad, which enabled me to do this work. I own a special thanks to Prof. Dr. Tahseenullah Khan, Department of Earth and Environmental Sciences, Bahria University for his expert opinion and guidance. I am grateful to Dr. M. Saeed Khan Jadoon (OGDCL) for his technical support. I am also thankful to Higher Education Commission (HEC) for financial assistance.

I own and also appreciation to Imran Ahmad (Charsadda University), Qamar Mehdi (HDIP), Shamshad Akhtar (OGDCL), Muhammad Jahangir (Spud Energy), Shahzad Anjum (Spud Energy), Dr. Nadeem Ahmad (MOL), Mohsin Munir (OGDCL), Muyyassar Hussain (LMKR), M. Fahad Mahmood (Bahria University), Muhammad Ibrar, Sardar Umar Farooq, Hammad Ghani, Muhammad Yasin, Hamza Zaman, Muhammad Fahad, Muhammad Rizwan, Muhammad Irfan, Azhar Iqbal, Waqar Ahmad, Salman Khurshid, Syed Zulqarnain Haider, Tassawar Hayat, Shah Faisal Zeb and Waseem Abbas, who prepared me for thesis work.

I am very much thankful to my parents, family members and friends, their prayers and love was with me all the time.

ABBREVIATIONS

Alg	Alginite
APEC	Asia Pacific Energy Consulting
Bit	Bituminite
BOE	Barrels of oil equivalent
CG	Datta shale from Chichali gorge
Ch	Chanda
ChD	Chanda deep
CPI	Carbon preference index
DB	Durabond (double faced Aluminum Composite)
DCM	Dichloromethane
DF-1	Shale extract from Chanda-1
DF-D1	Shale extract from Chanda deep-01
FID	Flame ionization detector
Fm.	Formation
Ft.	Feet
Ga	Billions of years
GCMS	Gas chromatography mass spectrometry
H	Hopane
HH	Homohopanne
H/C	Hydrogen to carbon ratio
HCs	Hydrocarbons
HCl	Hydrochloric acid
HI	Hydrogen index
IFP	Institut Francais du Petrole
Ine	Inertinite
IR	Infrared
km	Kilometers
Lip	Liptinite
m	Meters
Ma	Millions of years
MID	Multiple ion detection

NSO	Nitrogen sulphur oxygen
O	Oleanane
OEP	Odd over even predominance
OGDCL	Oil and Gas development company limited
oLi	Other liptinite
OM	Organic matter
POL	Pakistan oilfields limited
PPL	Pakistan Petroleum limited
RE	Rock Eval analysis
rpm	Rotation per minute
Ro/VR	Vitrinite reflectance
S	Sterane
Spo	Sporinite
TAR	Terrigenous/aquatic ratio
TCT	Tricyclic terpane
TeCT	Tetracyclic terpane
OI	Oxygen index
Vs.	Versus
Vit	Vitrinite

CONTENTS

CHAPTER 1
INTRODUCTION

CHAPTER 2

GEOLOGY AND TECTONICS OF THE AREA

CHAPTER 3

METHODOLOGY

CHAPTER 4

RESULTS AND DISCUSSION

FIGURES

TABLES