IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 8, Issue 1 Ver. I. (Jan. 2015), PP 46-50
www.iosrjournals.org

Pseudo-Source Rock Characterization

[1]Swapan Kumar Bhattacharya, [2]Juwita Hapaz
Universiti Teknologi Petronas, Bandar Sei Iskandar,
31750 Tronoh, Perak Darul Ridzuan, Malaysia.

Abstract: *Pseudo-Source rocks are those naturally occurring rocks which appear to be good source rock by conventional analysis but actually these rocks do not contribute hydrocarbon in the basin. A pseudo-source rock contain appreciable TOC, show high generation potential during pyrolysis, kerogen in the rock may also show high maturity but it will not generate hydrocarbon if the rock maturity is less than the kerogen maturity. This is possible when a matured kerogen is incorporated in the sediments during deposition. For example, when a matured coal is weathered and deposited with fresh sediments, or if sediments are deposited through a seeped oil column whereby appreciable amounts of asphaltenes and resins are incorporated in the sediments. In this work attempt has been made to test pseudo-source rock characters using a synthetic rock prepared by depositing clays through an oil column. This synthetic rock is then thoroughly tested for source potential evaluation. Results indicate good source potential and perfect oil source correlations using GC and GCMS results although the rock is not matured to generate hydrocarbons.*

I. Introduction

It has been realized that the success of a hydrocarbon discovery in a petroleum prospect mostly depends on the presence or absence of a source rock around the area. The first concept of source rock was originated by John Newberry (1860) to describe Devonian Ohio Shale as the source of Pennsylvanian petroleum occurrence. This is an example of marine shale with marine organic matter. A major change in the concept of source rock took place in 1968 when concept of terrestrial source rock was introduced by Hedberg who suggested high wax oils are generated from terrestrial organic matter. Thereafter, concept of lacustrine source rock was developed (Fleet et al, 1988) in early eighties to distinguish oils from marine and terrestrial organic matter. As on today source organics and source environment do not have any importance in the definition of source rock. Any organic matter with considerable hydrogen concentration can generate petroleum in the oil window. Critical analysis of this present concept of source rock however reveals two fundamental problems that may cause failure of true source character. One of the problem is the nature of organic matter that points how average organic matters with low concentration of hydrogen relative to petroleum can generate petroleum (Swapan 2012)? The other problem is related to the maturity of source rock that points kerogen in the source rock may be differently matured than the inorganic host sediments.

A source rock is composed of naturally occurring syn-sedimentary minerals including the organic matter (Snider, 1934). It is necessary to remember here that this organic matter is critical decisive factor for petroleum generation. Incorporation of the organic matter in inorganic sedimentary rock can take place by the following means:

1 Dead organisms in the basin deposited with sediments or
2 Organic matter is transported from terrestrial part of the basin with sediments:
2.1 As dead organism, or
2.2 As recycled organic matter, or
3 Sediments may be contaminated
3.1 with floating oil column or syn-depositional migration, or
3.2 by encountering natural seepage while transportation.

Whatever may be the mode of incorporation, if organic matter is suitable to generate hydrocarbons for the prospects in the basin, then we can call it as the source rock of the producing oil, otherwise these will be considered as pseudo-source rocks. This is because all these pseudo-sources may have sufficient organic matter, also capable to generate enough pyrolysable products and kerogen in the rock may be matured also in the oil/gas window but since their organic matter is not suitable for generation they cannot source oil/gas in any reservoir. This is because kerogen in a source rock generates only when the environment of overall rock gets more matured than kerogen. A matured kerogen in the rock will remain in the same maturity till the whole rock undergoes in an environment of more maturity and finally the kerogen will generate and transform to higher maturity.

In a petroliferous basin, many a times' drilling encounters number of high TOC bearing fine grained rocks. If these TOC bearing rocks are immature or lean in organic carbon concentration then these are not

counted in source category. On the contrary it is possible that some of them contain high TOC, appreciable maturity and sufficient H/C but the maturity of organic matter is not consistent with thermal maturity of syn-depositional sediments. It happens when matured kerogen is directly added to sediments during deposition or during diagenesis of the rock. This is possible when coal as kerogen is directly added to sediments or if there occurs some syn-depositional or pre-diagenesis migration/seepage of hydrocarbons in the basin. Sediments get soaked with migratory hydrocarbons and in long run appear as potential source in the basin. Such rocks in a petroliferous basin that appear as a potential source rock with conventional parameters but geologically they are not true source in the basin, are termed here as pseudo-source rock. These pseudo-source rocks must be identified in the basin for proper evaluation of the basin hydrocarbon potential. The objective of this present work is to establish experimentally the possibility of occurrence such rocks in nature.

II. Methodology

To characterize pseudo-source rocks of hydrocarbon contamination a pseudo-source rock is prepared in laboratory by depositing kaolin clays in a specific long column (Fig.1) already filled with Dulang crude oil of peninsular Malay Basin. The column is also attached with heating facility using Palmer-Silicone Rubber Heating Tape and pressure facility using Kennedy Hydraulic Bench Press. Clay slurry was prepared by mixing 500 g of kaolinite clay sample and 25.0 g of Portland cement with sufficient water. 400 ml Dulang crude oil is placed in the column for the precipitation process. Clay slurry is then poured drop wise into the column. Once the sedimentation is complete the sample is left for 18 days with small overburden pressure to complete sedimentation process. Next, the sample is pressurized gradually to a maximum of 3.0 tonnes and simultaneously heated from 50^0C to a maximum of 70^0C. Both processes are carried out simultaneously for 35 days. After 35 days the sample is taken out and tested thoroughly for source rock characters.

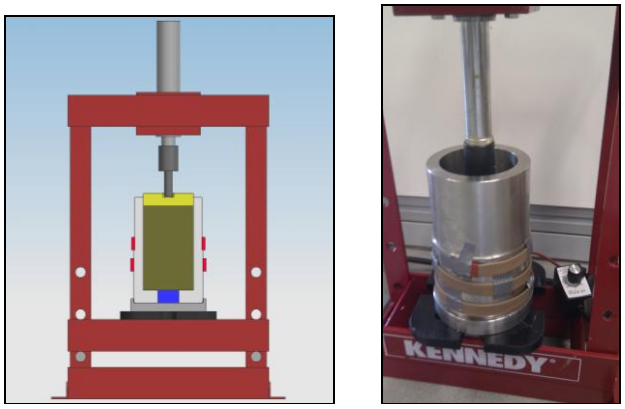

Fig.1: Left figure shows the schematic diagram of the instrument while on the right figure shows the actual instrument used for pseudo-source rock preparation.

III. Results and Discussions

Pseudo-source rock has been analyzed in Panterra orogenic laboratory in Kuala Lumpur, Malaysia. The amount of TOC is shown to be 0.51% which appears to be marginal for a source rock. However, such low TOC source rock is also seen in Tertiary Green Shale of Columbia (0.54). Low TOC in the prepared sample is because of the low asphaltene content (0.50%) of Dulang oil. Basically it is the asphaltene of crude oil that is remained in the rock to contribute TOC.

Pyrolysis results (Table-1) suggests good source rock except the value of high S_1 and related high PI. Parameters S_2, T_{max} and HI all suggest very good source. Tmax value of 451^0C and its equivalent Vro (0,018*Tmax -7.16 following Jarvie (2005)) of 0.958 suggest the rock is matured in the oil window.

Geochemical characters of the rock extract have been compared (Table-2) with Dulang oil using (i) liquid chromatography and (ii) GC-MS results. Results show very good match with Dulang oil. Oil – source correlation using extract GC and Dulang oil GC (Fig.2) also shows very good match suggesting Dulang oil has been sourced from this rock. Biomarker maturity parameters (i) Tm/Ts (ii) C29 20S/(20S+20R) and (iii) C30 Moreatane / Hopane also show comparable results. Oil – Source correlation using 123 fragmentogram (Fig.3), 191 fragmentogram (Fig.4) and 217 fragmentogram (Fig.5) all show very good correlation.

All these together suggest the synthetic rock can be the source for Dulang oil but the rock has not been heated above 70^0C suggesting it cannot be matured in the oil window. Although biomarker maturity and rock-eval maturity measurements suggest the rock is lying in the oil window, actually it is the incorporated kerogen in the rock which attained oil window maturity before sedimentation and incorporated in the sediments afterwards. Sediments in the rock are still immature and kerogen is matured to generate oil.

Table-1: Pyrolysis results of pseudo-source rock.

S_1 mg/g	S_2 mg/g	S_3 mg/g	Tmax Deg.C	PI $S_1/(S_1+S_2)$	Pot.Yields (S_1+S_2)	HI $100*S_2/TOC$	OI $100*S_3/TOC$
1.95	1.65	0.52	451	0.54	3.60	324	102

Table-2: Geochemical Parameters of Dulang Crude oil and Pseudo-Source Extract

Parameters	Dulang Crude Oil	Rock Extract
API	36.8	
Wax%	10.17	
Saturate%	84.17	84.06
Aromatic%	13.82	13.93
NSO%	1.51	1.53
Asphaltenes%	0.50	0.47
Saturate / Aromatic	6.09	6.03
Pr/Ph	5.62	5.07
$Pr/n\text{-}c_{17}$	1.23	1.02
$Ph/n\text{-}C_{18}$	0.23	0.24
CPI	1.13	1.11
C_{27} Tm/Ts	0.45	0.45
C_{29} 20S/(20S+20R)	0.16	0.17
C_{30} Mor/Hop	0.18	0.17
Diasterane / Sterane	0.54	0.52
C_{27} Sterane	7	8
C_{28} Sterane	23	23
C_{29} Sterane	70	69
Sterane / Hopane	0.07	0.06

Fig.2: Oil-Source correlation using GC of Dulang Crude oil and Pseudo-Source Extract

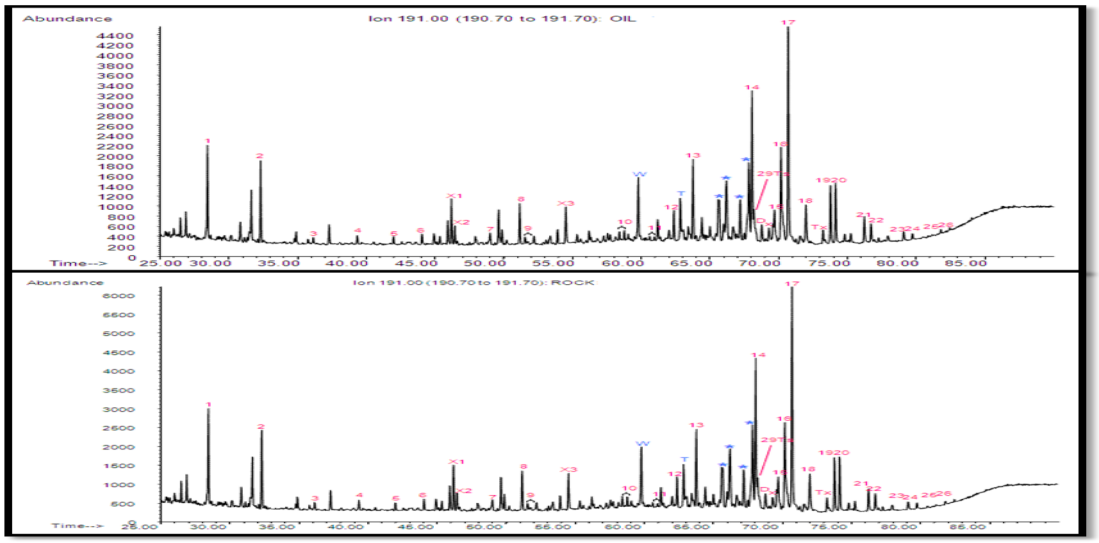

Fig.3. Oil-source correlation using m/z 123 fragmentogram of Dulang Crude Oil and pseudo-Source Rock Extract

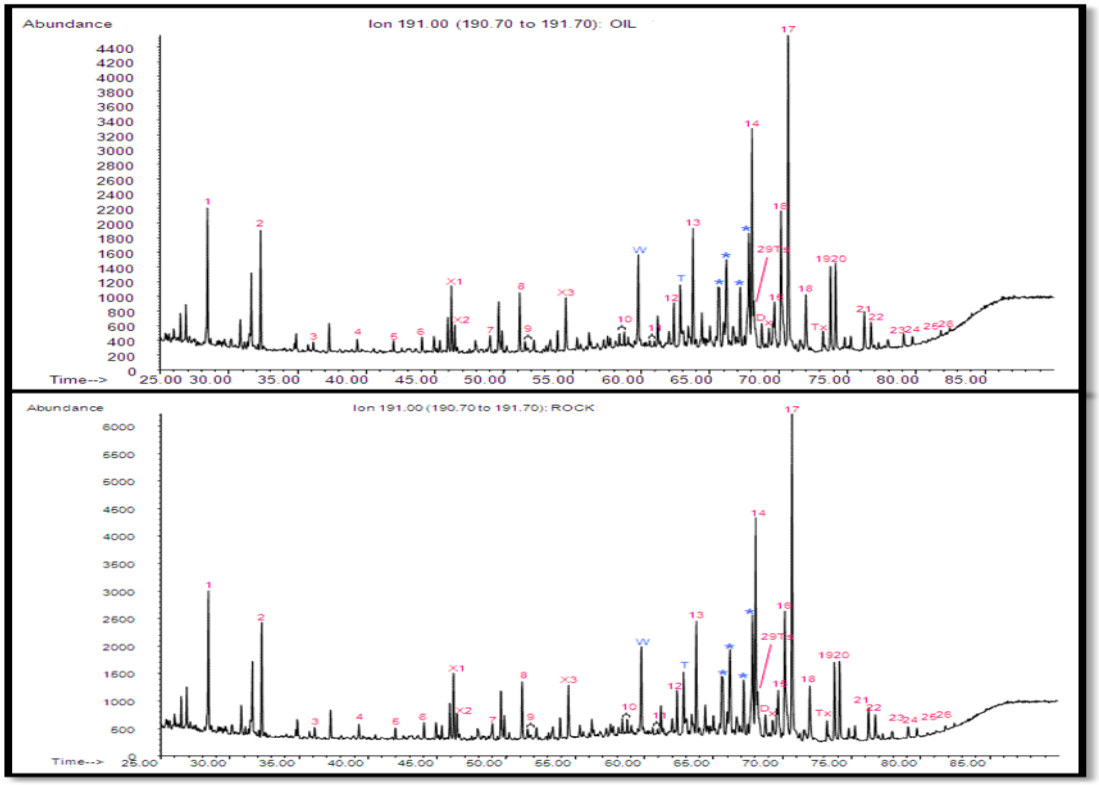

Fig.4. Oil-source correlation using m/z 191 fragmentograms of Dulang Crude Oil and pseudo-Source Rock Extract

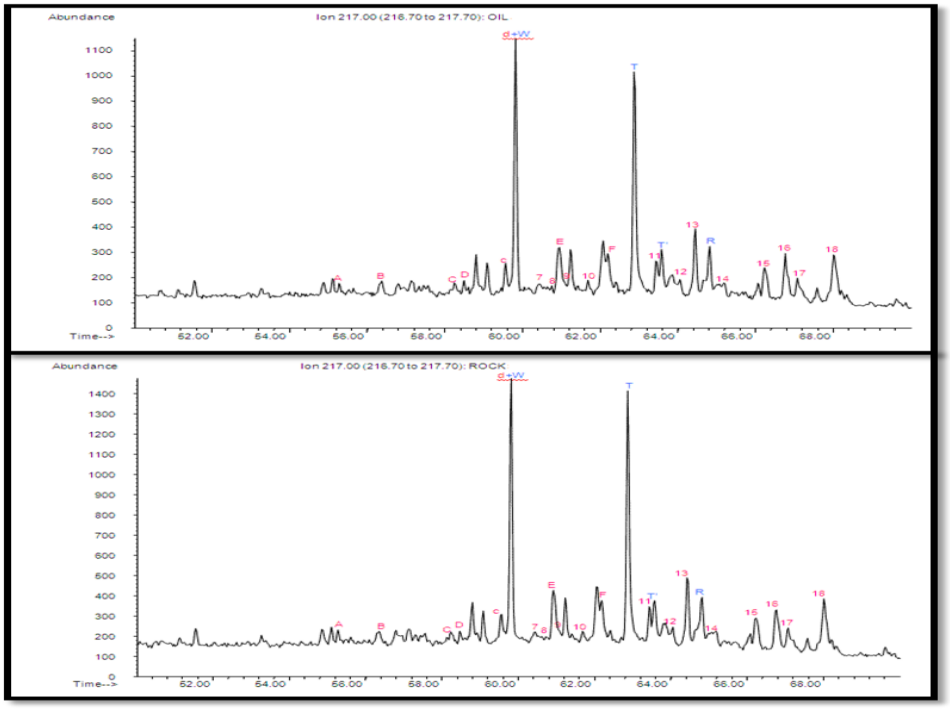

Fig. 5. Oil – Source Correlation using m/z 217 fragmentogram of Dulang Crude Oil and Pseudo-Source Rock Extract

IV. Conclusions and Recommendations:

Based on the above results it is concluded that all TOC bearing rocks are not true source rocks even though the rocks show high generation potential during pyrolysis and the kerogen in the rock show appreciable maturity. These rocks which appear good source but cannot contribute generation in the basin are pseudo-source rocks. If kerogen in the pseudo-source rock is capable to generate petroleum then it will generate as true source

only when thermal maturity of inorganic sediments will exceed the maturity of kerogen. In true source rocks organic matter is converted to kerogen during diagenesis and gradually gets matured with the rock but in pseudo-source rocks matured kerogen is directly introduced in the rock. These pseudo-source rocks can also behave as true source when the maturity of the host inorganic rocks exceed the incoming kerogen maturity.

It is therefore recommended to sincerely identify how the organic matter has been incorporated in the sediment before describing a source rock. It is also recommended to carry out research to develop methodology to find out thermal maturity of isolated host sediments and kerogen separately.

Acknowledgement:

Authors acknowledge financial help of Universiti Teknologi Petronas (UTP) to carry out this work

References:

[1]. John Newberry, 1860, The Rock oils of Ohio. Agricultural Report for 1859.
[2]. Hedberg, H. D., 1968, Significance of high wax oils with respect to the genesis of petroleum, AAPG Bulletin, 52, 736-750
[3]. Fleet, A. J., K. Kelts and M. R. Talbot (eds.), 1988, Lacustrine Petroleum Source Rocks, Geological Society Special Publication 40. Oxford Blackwell Scientific Publications.
[4]. Bhattacharya S. K., 2012, Changing Concepts of Petroleum Source Rocks, Lap-Lambert Academic Publishing, pp33-34.
[5]. Daniel M Jarvie, Ronald J. Hill and Richard M Pollastro, 2005, In Cardott B. J. (ed.) Unconventional energy resources in southern Midcontinent, 2004 symposium
[6]. Snider, L. C. 1934, Current ideas regarding source beds for petroleum. In W.E. Rather and F. H. Lahee (eds.), Problems of Petroleum Geology. AAPG Memoir 1. Tulsa: American Association of Petroleum Geologists, pp. 51-56.