Surface Geochemical Analysis on Outcrop Sample of Block PM322 Shoreline, Pantai Bagan Lalang

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Received: 11 April 2019
Accepted: 19 June 2019
Published: 30 June 2019

ABSTRACT

The use of surface geochemical exploration methods is based on the concept that all petroleum accumulations suffer some leakage to shallower intervals and eventually to the surface. The objective of this study is to analyze geochemical properties such as moisture content, grain size, and mineral properties of the outcrop sample. Subsequently to relate these geochemical properties with petroleum parameters such as porosity, permeability, fluid flow, type of rock, minerology, and chemical composition. Three samples were collected within 100m x 100m parameters to provide an average value result. The samples were taken 20cm below surface and on the shoreline of Pantai Bagan Lalang. The moisture content and organic content of the sample can be known as a percentage of its oven dried weight with its wet sample. The mechanical sieve method was conducted in accordance with ASTM D 422 for the grain size distribution analysis. Lastly, X-ray diffraction analysis was conducted to identify mineral composition based on the peak from a graphical result computed from the XRD machine. Water content analysis results was then related with the fluid flow of the samples while soil organic content was studied to identify shale deposition. Besides, grain size distribution analysis provided porosity range value and permeability overview when correlated with grain size and sorting of the samples. XRD analysis provided graphical data of mineral composition that can be correlated with sample history. In conclusion, Pantai Bagan Lalang indicates a negative quantitative value of a potential reservoir would have.

Keywords: *Geochemical analysis, beach sand, outcrop sample, environment, accumulation of petroleum*

INTRODUCTION

The conventional methods that are commonly used in oil and gas exploration include geology and geophysical seismic survey, gravity survey, electromagnetic survey, and exploration wells and are very costly. Such methods also cause local destruction and have significant impacts on the environment (Pearson et al., 1992; Marsh, 1991). For example, Weilgart et. al (2013) concluded in her reseach on airgun noise which resulted from airgun seismic survey to be considered as one of the major pollutant to the marince environment. Hence, the surface geochemical surveys were developed and are helpful in identification of hydrocarbon presence (Sechman et al., 2011; Sechman et al., 2012).

Geochemical surveys focus on the process of chemical composition and chemical change in the Earth's crust. Geochemistry utilizes the principle of chemistry to explain the mechanisms regulating the working – past and present – of the major geological systems such as the Earth's mantle, its crust, its oceans and its atmosphere (Albarède, 2003). Success of surface geochemical surveys was proven using positive anomaly out of 1344 drilled wells, 18 per cent dry holes and 82 per cent discoveries were identified (Schumacher, 2000). Subsequently, in the oil and gas industry, surface geochemical exploration was widely used to search for forecasting hydrocarbon deposits.

Basically, geochemical techniques record and analyze the concentrations of gas on the surface area that have migrated from deep accumulations (Sechman et al., 2011). The gas has migrated upward, along the faults or fractures, from subsurface hydrocarbon accumulations to the near surface environment, by diffusion and effusion, which results in surface hydrocarbon anomalies (Mani et al., 2011).

This paper presents the results of surface geochemical surveys conducted over the selected petroleum prospective structures at operated Block PM 322 located in the Melaka Straits on the Malay side of the Central Sumatra Basin. It also covers up to offshore of West Coast Peninsular Malaysia that includes shoreline from Lumut, Perak to far South, and Johore.

An understanding of the water content in soil spreading tremendously as free water in all oil soil is practically accepted among researchers. This can be concluded from experiments of Crowther and Haines (1924) in their study of electro endosmosis in soil. Moisture content of soil less than 14 per cent will be regarded as no presence of endosmotic flow.

The significance of organic matter in oil and gas can be further explained by understanding the concept of sufficient organic matter to generate petroleum and sufficient porosity and absorption sites to retain that petroleum. Terminologies used to describe this type of reservoir and the plays involved, have varied considerably over the past decade (Passey et al., 2010). Studies of sedimentology will broaden the understanding on distribution and geometry of reservoir rock in a sedimentary basin and rock properties changes during its burial (Bjorlykke, 2010). Porosity and permeability of sediments are dependent on particle size and relies on the grain shape and sorting.

The objective of this study is to analyze geochemical properties such as moisture content, grain size, and mineral properties of the outcrop sample. Subsequently to relate these geochemical factors with hydrocarbon properties which includes porosity, permeability, fluid flow, type of rock, minerology, and chemical composition.

EXPERIMENTAL

Outcrop Sample

PM 322 Block covers a wide area from seaside to offshore, and from Perak to Johor. Pantai Bagan Lalang was chosen because of distance flexibility between laboratory and sample location. Pantai Bagan Lalang also possessed the least probability to have undergone reclamation due to the government's nature preservation efforts. A Hollow cylindrical object approximately 25cm with a diameter of 7cm was used to achieve appropriate depth in acquired fresh soil sample.

Three localities were marked with approximately 20cm distance from each other as shown in Figure 1. The top sand was removed using trowel down to at least 20cm below. Then, the hollow cylindrical objects were submerged into the sand and been transferred into a box. The samples weight was approximately 700g each.

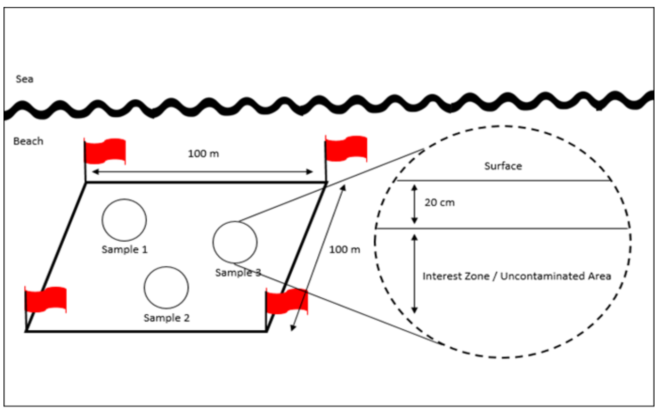

Figure 1: Interest zone of sand sample acquisitions

Moisture Content Analysis

The moisture content of soil can be known as a percentage of its oven dried weight. The process involves drying off 20g of wet soil in 100˚C oven overnight for 24 hour. All three samples were tested for an average result. The soil moisture content, (W %) can be calculated using the formula below:-

$$W\,\% = \frac{(M_2-M_3)}{(M_3-M_1)} \times 100\% \qquad (1)$$

Where,
M_1 = Mass of beaker, g

M_2 = Total mass of 20g wet sample and beaker, g
M_3 = Total mass of dried sample and beaker at 100˚C, g

Organic Material Content Analysis

Dried soil samples from the Moisture Content Analysis were used in Organic Material Content Analysis. All three dried samples were then transferred to a furnace with a temperature of 400˚C for 3 hours. M_1, M_2, and M_3 were results from the tabulated data of Moisture Content Analysis and M_4 represent total mass of both dried sample at 400˚C and the beaker. The soil organic material, (SOM) was determined using the formula shown below;

$$SOM\ \% = \frac{(M_3 - M_1) - (M_4 - M_1)}{(M_3 - M_1)} \times 100\% \qquad (2)$$

Grain Size Distribution Analysis

The mechanical sieve method was used to determine the distribution of coarse, large and fine grain size. It was conducted in accordance with ASTM D 422 (ASTM, 2007). In grain size distribution analysis, the sorting was measured as the ratio of the larger to smaller particle sizes in the sediment. 600g of soil were dried on a pan for 24 hours in a 100˚C oven. However, only 500g of the dried sample wa needed to be placed on top of the sieve.

A series of different mesh sizes or micron were arranged in a decreasing diameter manner. Sieve number of 500, 400, 300, 150, 125, 63 micron were arranged as shown in Figure 2. The mechanical sieve shaker was set to run for 1 hour to allow the sand particles to pass through evenly. Each sieve was weighed using electrical balance before and after the sieve to acquire the percent passing. A graph was constructed, and a grain size distribution curve was obtained. The graph can be used to measure uniformity coefficient, C_u and curvature coefficient, C_c. Both coefficients were determined using the formula tabulated below:

Table 1. Uniformity coefficient, C_u and Curvature coefficient, C_c formula

Uniformity coefficient, C_u	Curvature Coefficient, C_c
$\frac{D_{60}}{D_{10}}$	$\frac{(D_{30})^2}{D_{60} \times D_{10}}$

Where,
D_{60} = diameter corresponding to 60% finer in particle size distribution
D_{30} = diameter corresponding to 30% finer in particle size distribution
D_{10} = diameter corresponding to 10% finer in particle size distribution defined as the effective

Figure 2: Mechanical sieve shaker with different mesh sizes

X-Ray Diffraction, (XRD) Analysis

5g of sample was grounded using mortar until the sample become powder. Only 1 sample was required to run the XRD because the result will hardly vary within 100m parameter. Mineral composition can be known based on the peak from a graphical result computed from the XRD machine.

RESULTS AND DISCUSSION

Water content affecting fluid flow

The water content percentage existed in all the three samples but in low values which were 5.55%, 4.15% and 5.18% respectively as shown below in Table 2. It shows no endosmotic flow of water existed within the samples area since the moisture content was below 14%. This statement is supported by Crowther and Heins (1924) experiment on electro endosmosis in soils. However, the soil used by Crowther and Heins (1924) were sand cores and oil accumulation existed whereas the soil water content analysis conducted were on an unknown location of oil accumulation.

Table 2: Results obtained from soil water content analysis

Analysis	**Water Content**			
Sand	**M_1, (g)**	**M_2, (g)**	**M_3, (g)**	**W, (%)**
Sample 1	62.24	82.2	81.15	5.55
Sample 2	60.25	80.34	79.54	4.15
Sample 3	60.23	80.33	79.34	5.18

From the results, it can be deduced that low percentage of water content means the samples are less porous and permeability. This in short conclude that the samples are not suitable for hydrocarbon presence.

The relationship of Organic Content with Shale

The average percentage of soil organic material, SOM for all samples of investigated area was 0.96% as shown in Table 3 below. It is considered low probably due to the parent rock or grain itself. There were parent rocks that were suitable for living organisms and some were not suitable for living organisms. The samples taken on a shoreline (beach) where there were rarely living organisms on the beach e.g. plants, animals, or sea creatures. Therefore, this explains the low value of organic material. However, if the sample had been collected at the bottom of sea or shallow depth of the sea, the SOM will be high due to the variety of organic life in the wide sea.

Table: Results obtained from the soil organic material analysis

Analysis	Water Content		Organic Content	
Sand	**M_1, (g)**	**M_3, (g)**	**M_4, (g)**	**SOM, (%)**
Sample 1	62.24	81.15	80.94	1.11
Sample 2	60.25	79.54	79.38	0.83
Sample 3	60.23	79.34	79.16	0.94

The effects of grain size and sorting on porosity

The samples collected had the range of 500microns to 63microns in grain size as shown in Table 4 and had porosity range from 30% to 38%. Results showed porosity increased from about 26% to 42% as the sand grains decreased from 1000microns to 45microns. In theory, grain size does not affect porosity directly for well sorted grains in nature. However, the effect of sand grain size on porosity could be due to sand grain deformation from spherical shape shown in Figure 3. Porosity increases with the decrease in particle size. It is highly dependent on the packing (Fetter, 1994). In other context, grain size does not affect porosity but the sphericity of sand grain affects porosity (Chillingrian, 1975).

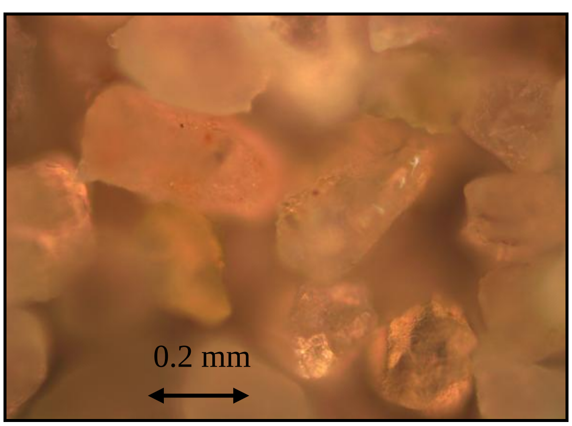

Figure 3: Microscopic view magnified by 20x of sand sample

Well sorted sediments generally have higher porosity then poorly sorted sediments with the facts that if a sediment contains a range of particle sizes then the smaller particles may fill in the voids between the larger particle. A grain size distribution curve was developed in order to calculate the uniformity coefficient.

Table 4: Range of grain size exist within the samples parameter

Grain Size (Micron)	Diameter (mm)	Size Terms
500	0.5000	Course Sand
400	0.4000	Medium Course Sand
300	0.3000	Medium Course Sand
150	0.1500	Fine Sand
125	0.1250	Very Fine Sand
63	0.0630	Course Silt

The typical characteristic (Bear, 1972) of the steep curve from Figure 4 below shows poorly graded grain. D_{60}, D_{30}, and D_{10} were extracted from the graph to obtained uniformity coefficient, C_u and curvature coefficient, C_c using the formula in Table 1.

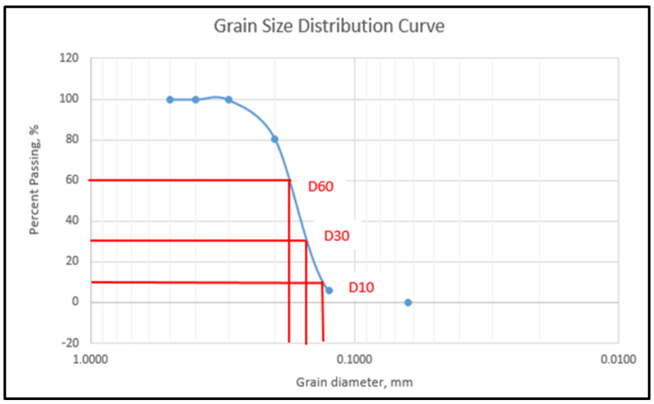

Figure 4: Plotted grain size distribution curve

Comparing the results with standard grade classification of soil and sand (ASTM, 2011), the sand sample exist as a poorly graded or uniformly graded of sorting with uniformity coefficient, C_u of 1.019 and curvature coefficient, C_c of 1. Low value of Cu indicates soil mass consist of small ranges of particle size. It may also due to the soil history where the samples originated from intermediate maturing soil deposit.

The effects of grain size and its distribution on permeability

Permeability is related to the amount of free space existing in order for the fluid to flow. Therefore, the grain size distribution will affect the permeability of the experimented sample. If the fluid paths were blocked due to poorly sorted sediment size, it will reduce the amount of fluid that could flow through "tortuosity constant". However, permeability in sediments is not only dependent on grain size and sorting but also grain shape and its packing. In explanation for soil mechanics, if small particles mixed into a soil, it will decreases its permeability (Kachi et al., 1972). Therefore, beach sand is considered homogenous in terms of distributions (Bear, 1972) and permeability of sand sample concluded as low in Block PM322. The Beach Sand has roundness effects due to its transportation history (Packwood, 1980).

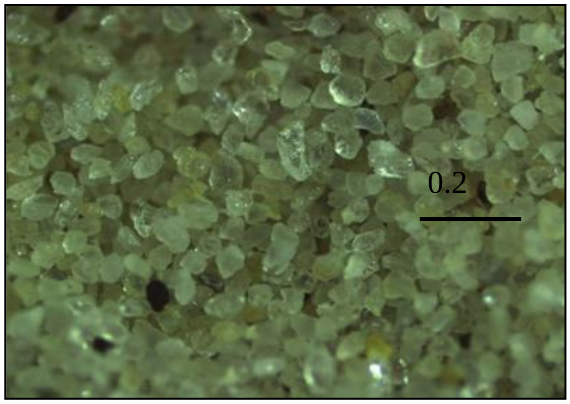

Figure 5: Microscopic view magnified by 4x of sand sample

Sphericity depends on the shape of the grains. It measures how close grain comes to being spherical or elongate as shown in Figure 5. The low sphericity shape probably will result in poorly grain sorting and therefore possessed a low permeability value.

Relationship of mineral and sand history

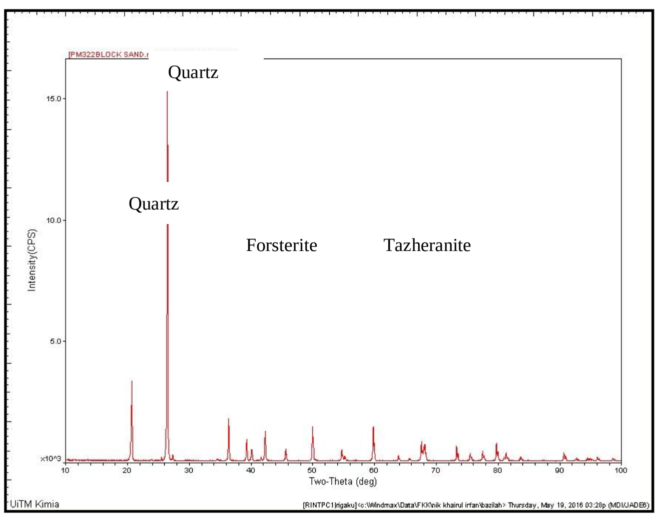

Figure 6: Graphical results plotted from XRD analysis

X-Ray Diffraction, XRD analysis indicate a few peaks as shown in Figure 6. The most visible mineral's peak interpreted as Quartz, Q, Forsterite, Fo and Tazheranite, T. Quartz is the second most common mineral in Earth's crust and is called Silicon Dioxide, SiO2 for its chemical name. It exists in most igneous and practically all metamorphic and sediment rocks. Quartz shows the highest intensity compared to other mineral and at one point cover up the biggest area of x-ray. Besides, sandstone was composed of quartz or feldspar therefore it can be classified as a clastic sedimentary rock existed in the history of Pantai Bagan Lalang. However, there were no indication of Ferrosilite, Fs and Antigorite, A. Anorthite where it can classify facies and deposits exist within the parameter. While, existence of Forsterite, Fo indicates high content of magnesium and is associated with igneous and metamorphic rock.

CONCLUSIONS

Geochemical properties such as the moisture content, grain size, and mineral properties can be explained from PM322 block reservoir characteristic. It can be concluded that the moisture content can be related with fluid flow. The samples were identified with no endosmotic flow within the grain due to water content lower than 14%. Organic content can be related with shale deposition but unfortunately it also shows poor value probably due to inaccurate location selection. However, results from both grain size distribution analysis and XRD analysis shows different characteristic.

Factor of grain size and sorting can be related with porosity in grain size distribution analysis. The grain size of 500microns to 63microns shows porosity range of 30% to 38%. The ranges were obtained by ratio method comparing grain size and porosity results from other journals and research. A graph was plotted based on the percent passing and uniformity coefficient, C_u of 1.019 and curvature coefficient, C_c of 1 was acquired. These values show the samples possessed poorly graded or uniformly graded soil. The results were supported because Pantai Bagan Lalang exist as quaternary deposits and possessed an intermediate maturing soil deposit.

The permeability of the sample was described as low when comparing with its grain sizes but the homogeneity of the sample does not eliminate the possibility of fluid to flow. XRD analysis shows positive existence of quartz indicating clastic sedimentary rock existed in Pantai Bagan Lalang.

Therefore, fluid flow, shale deposits, porosity, permeability, and organic history can be identified and related with reservoir parameters. However, the selection of location is important as different area possessed different parameters. Through geochemical analysis conducted, Pantai Bagan Lalang indicates a negative qualitative and quantitative value of a reservoir. The research was conducted on a shoreline and all the results obtained show characteristics correlating to what a shoreline would have.

Acknowledgements
The author would like to thank to Universiti Teknolgi Mara (UiTM) for this opportunity.

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