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MICROSEISMIC DATA ANALYSIS USING MATLAB 2010 FOR THE DETERMINATION OF HYDROCARBON PRESENCE IN THE FIELD "LCY" OMBILIN BASIN

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ABSTRACT

Research using passive seismic methods has been performed on several oil fields around the world. In this study, the main result is the emergence of anomalous spectral frequency in range 2 - 6 Hz, at points measured just above the hydrocarbon reservoir. LCY-1 and LCY-2, both with hydrocarbon indications, were selected for analysis with passive seismic survey to delineate the extent of hydrocarbons in the "LCY" Field, Ombilin Basin West Sumatra. While the problem is limited to this research is the data used in the form of secondary passive seismic data processing performed using Matlab2010 software and mapping anomalous dispersion spectrum maximum value using software Surfer10.

In the acquisition step, measurements were recorded at 13 locations: 2 points experimentally measured for 24 hours, 9 points measured pioneer for 3 hours and 2 exploration wells were measured for 3 hours.

Based on the spectrum of anomalies arising at points of measurement, higher values of the spectrum occur in the South when compared with the North. This indicates potential for hydrocarbon accumulations are greater in the South. It can be concluded that the direction of migration of hydrocarbons in this basin is from NW to SE and this trend is supported by the structural framework in the area.

Keywords: *Matlab2010, passive seismic, petroleum system, maximum spectrum anomaly, Surfer10*

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INTRODUCTION

Passive seismic surveys for hydrocarbon exploration is a new method in Indonesia. The method originated in 1997 with the discovery of an interesting phenomenon, namely the existence of microseismic signals above a hydrocarbon reservoir and not detected on the surface above the medium that did not contain hydrocarbons. Above the oil reservoir, the natural earth noise spectrum increased sharply at a frequency of 2 - 6 Hz. This phenomenon has been confirmed in different locations, with different reservoirs in different countries, with different geological conditions and different environments (Suryanto and Wahyudi 2008). These observations lead to the development of a method to directly detect hydrocarbons that can be used both in exploration, field development and in monitoring hydrocarbon fields.

The purpose of this study is:

1. Implement new passive seismic survey method to confirm hydrocarbons in the LCY field.

2. Delineate the extent of hydrocarbons at LCY Field, Ombilin Basin.

REGIONAL GEOLOGY

A. Ombilin Structure

Based on geological and geophysical data, Ombilin Basin is expressed as a graben formed by pull-apart movement during Early Tertiary, followed by tensional tectonics in connection with the strike-slip movement along the Great Sumatra Fault zone. Subsequent erosion and faulting hinder reconstruction of a more accurate configuration for Ombilin Basin (Figure 1).

Based on seismic data, there are at least two types of trapping mechanisms found in the Ombilin Basin, namely:

- Structural folds and faults as in Sawahtambang where most structural traps exhibit strong compression and a model of the up-thrown trap.
- The combination of structural and stratigraphic traps may occur in a complex inverted graben delta in the region of Southwest Bukit Barisan.

B. Stratigraphy

Ombilin Basin stratigraphy can be described from the Sinamar-1 data, the well drilled by PT CPI in 1984. General stratigraphic sequence of Ombilin Basin from older to younger: Pre-Tertiary basement, Sangkarewang Formation, Sawahlunto Formation, Sawahtambang Formation and Ombilin Formation (Figure 2).

DATA AND METHODS

A. Data

Passive Seismic measurements were recorded at 13 locations in LCY Field, i.e. a test point, RCW 10 points and 2 points at wells (LCY-1 and LCY-2). The secondary passive seismic data were processed using the software Matlab 2010. The study stages are illustrated graphically in flow diagram Figure 3.

B. Methods

1. *Micro-seismic waves*

Errington (2006) explains that micro-seismic waves generate a mechanical wave that spreads out from the source in the form of longitudinal waves and transverse waves. Spectral anomalies with low frequency (<10 Hz) of micro-seismic signals recently have been used for the detection of hydrocarbons directly. For example Dangel et al (2003) investigated the micro-tremor to find hydrocarbon linking low-frequency spectral anomalies in a hydrocarbon reservoir in the Middle East. Low-frequency spectral analysis for hydrocarbon exploration has been done by the Russians since the 1990s. The spectrum of micro-seismic waves displays different frequencies in the presence of hydrocarbon reservoirs compared to areas with no hydrocarbons (Figure 4).

2. *Causes 2-4 Hz anomalies*

Causes of the anomaly frequency in the range of 2 - 4 Hz is still being debated many experts. But there are at least two theories that attempt to explain the emergence of the phenomenon (Holzner et al, 2006), namely:

1. The existence of resonance amplification occurs in the pores of the reservoir scale, in which seismic energy is trapped in the multi-phase medium (reservoir hydrocarbons) that produces resonance at a new energy level.
2. Scattering resonances due to the impedance contrast between reservoir rocks around which turn the tide of micro-seismic background into new seismic waves that are at a certain low frequency range.

RESULTS

This experimental study involved processing of passive micro-seismic signals recorded at 11 stations and 2 control points at wells LCY-1 and LCY-2 (Table 1). The objective was to determine the characteristics of micro-seismic waves measured at a known oil well and apply the characteristics of the waves at experimental points so as to obtain a map of the distribution characteristics of micro-seismic waves in the presence of a hydrocarbons.

Figure 5 depicts the results of micro-seismic data processing at station RCW 11 and well LCY-1 using Matlab software. One can see that there is a 4-6 Hz anomaly at both recording locations.

Figure 6 is a map of the distribution of the average spectrum of anomalies, which can be interpreted that the spectrum of anomalous wells LCY-2 had a higher response than LCY-1 wells indicate that the hydrocarbon potential of the wells LCY-2 larger than the wells LCY-1 and the spectrum of the maximum anomaly largest passive seismic measurement lies at the point of RCW 11. This indicates that at the point of RCW 11 has a greater potential than the hydrocarbon wells LCY-1 and wells LCY-2.

If we see the previous research (Figure 8), maximum micro-seismic spectrum anomaly located in the Kototuo anticline. This pattern supports the structure of the petroleum system in the area based on Ombilin Basin play map and same with the result (Figure 7). Hydrocarbon migrated from north to south filling anticline structures that exist in the area ranging from Sinamar Anticline and Kototuo Anticline, Palangki Anticline while yet known whether the hydrocarbons migrate up in this area or not because the measurements have not been to this area.

CONCLUSIONS

Based on the frequency spectrum of anomalies with 2 - 6 Hz as a reference, it can be concluded that:

1. The area containing hydrocarbons commonly has micro-seismic wave response of 2- 6 Hz. The presence of gas is indicated by 2 - 4 Hz anomaly, while 4 - 6 Hz anomaly relates to oil.

2. The largest passive seismic spectral anomaly occurs at point RCW11 indicating hydrocarbon potential greater than LCY-1 and LCY-2.

3. The spectral maximum anomaly LCY-1 well was at a frequency close to 2- 4 Hz indicating that the hydrocarbons in the well likely are gas, while in well LCY-2 spectral maximum is at 4 - 6 Hz indicating that the hydrocarbons in LCY-2 well as gas and least an oil.
4. Based on surveyed data points, the largest spectral maximums occur in the south indicating greater hydrocarbon potential than the north.

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TABLE 1

MAXIMUM ANOMALY SPECTRUM AND THE SPECTRUM OF ANOMALOUS VALUES IN THE AVERAGE FREQUENCY OF 2 - 6 Hz

No	Experimentation	UTM-X	UTM-Y	Maximum Spectral Density	Average Spectral Density
1	RCW1	xxx235	xxx4280	$7{,}75x10^{10}$	$28{,}2x10^{9}$
2	RCW2	xxx669	xxx0066	$2{,}41x10^{10}$	$2{,}1x10^{9}$
3	RCW3	xxx098	xxx0760	$4x10^{10}$	$1{,}8x10^{9}$
4	RCW4	xxx720	xxx9911	$0{,}57x10^{10}$	$3{,}5x10^{9}$
5	RCW5	xxx549	xxx0538	$1{,}6x10^{10}$	$1{,}5x10^{9}$
6	RCW7	xxx986	xxx5091	$1{,}87x10^{10}$	$1{,}2x10^{9}$
7	RCW8	xxx580	xxx4288	$1{,}6x10^{10}$	$2{,}7x10^{9}$
8	RCW9	xxx374	xxx2797	$15{,}6x10^{10}$	$54{,}9x10^{9}$
9	RCW10	xxx996	xxx1968	$35x10^{10}$	$190{,}1x10^{9}$
10	RCW11	xxx612	xxx1101	$104x10^{10}$	$512{,}7x10^{9}$
11	RCW6	xxx331	xxx9071	$1{,}6x10^{10}$	$1{,}35x10^{9}$
12	LCY-1	xxx791	xxx9911	$1{,}9x10^{10}$	$11{,}2x10^{9}$
3	LCY-2	xxx006	xxx4743	$2x10^{10}$	$1{,}2x10^{9}$

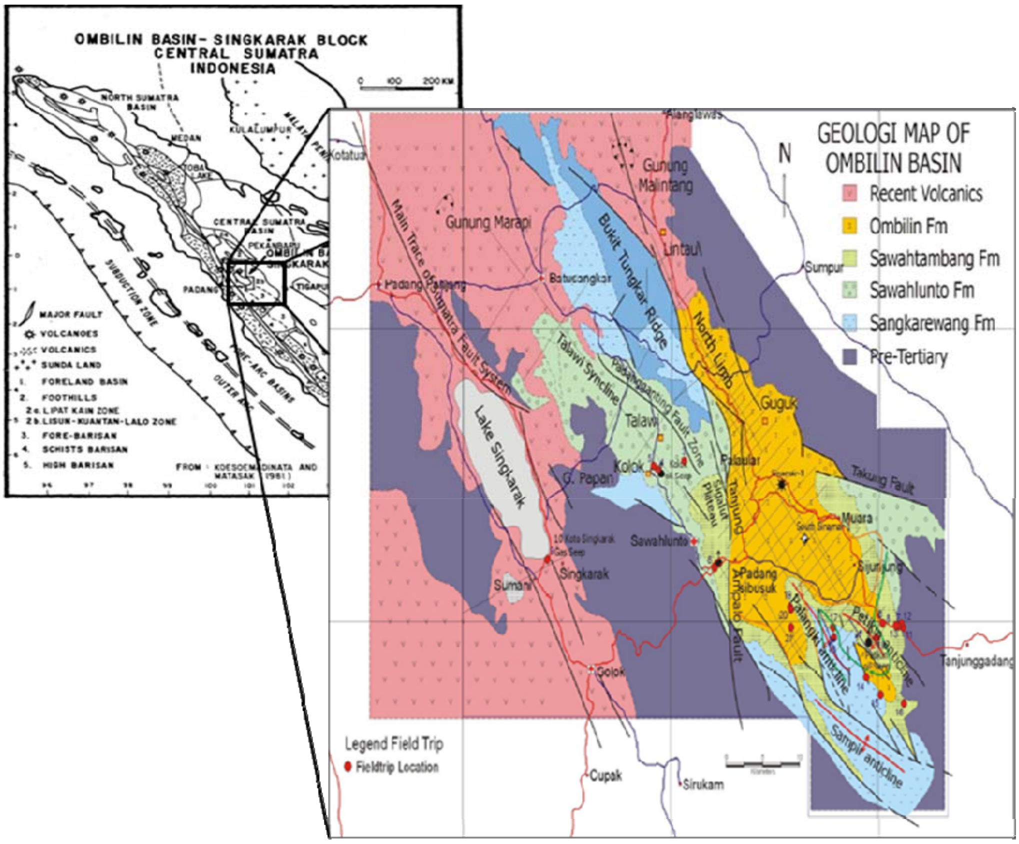

Figure 1 - Geology map of Ombilin Basin (Koesoemadinata and T. Matasak, 1981).

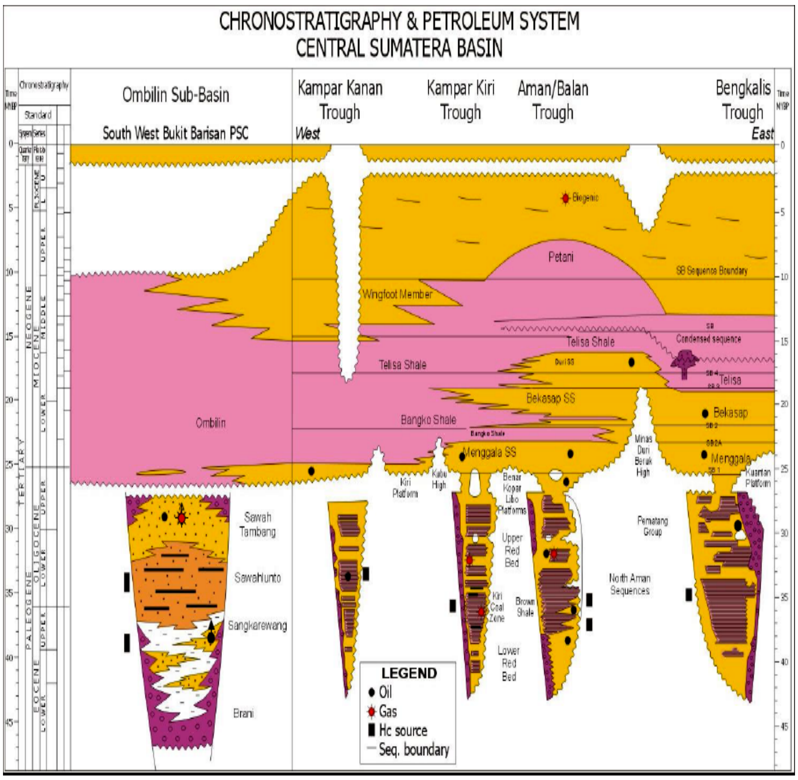

Figure 2 - Column Stratigraphy and Petroleum System South West Bukit Barisan Block (Koesoemadinata & Matasak, 1981).

DATA AND METHODS

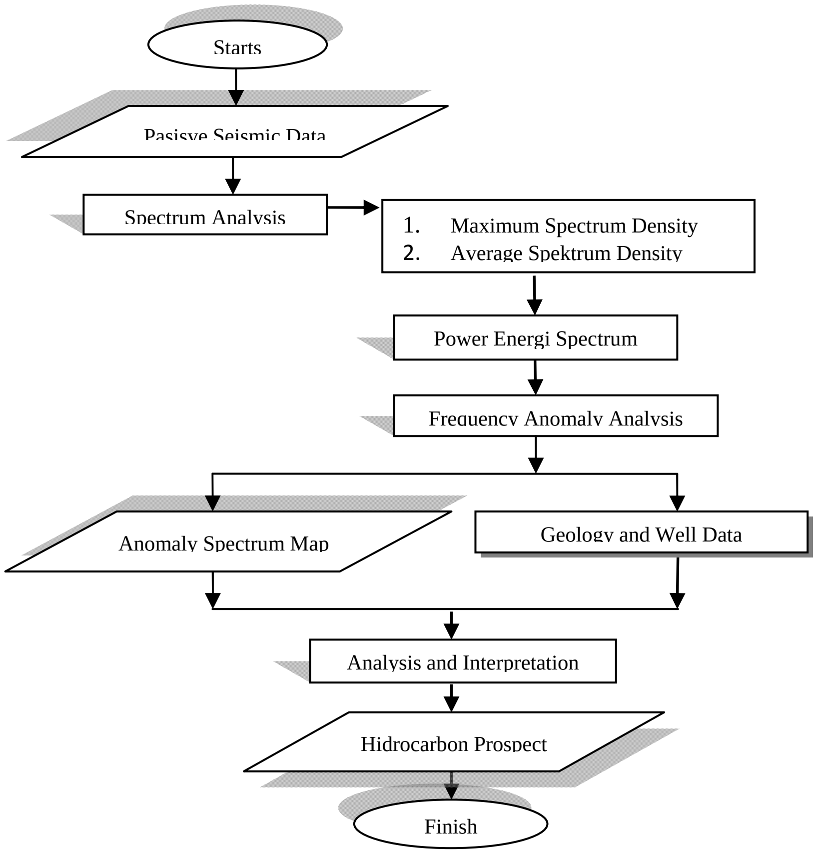

Figure 3 - Flow Chart.

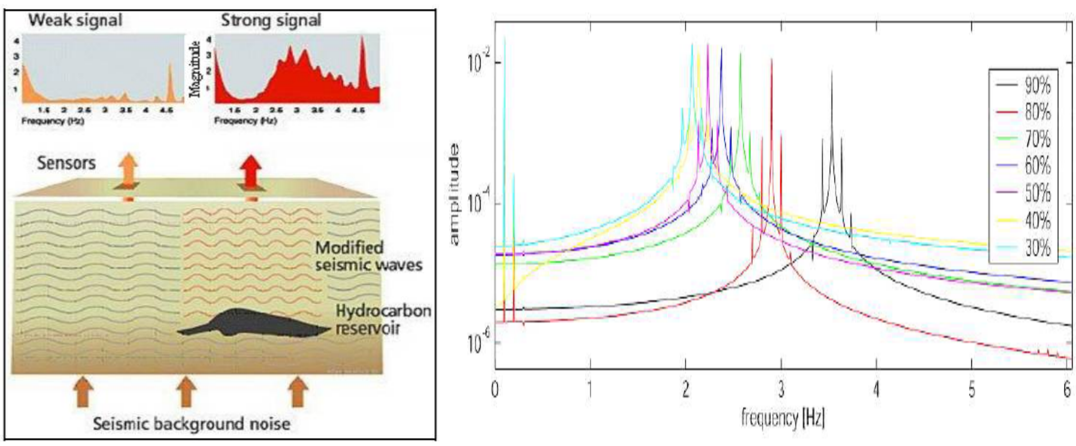

Figure 4 - Seismic background anomaly spectrum (Holzner et al, 2005).

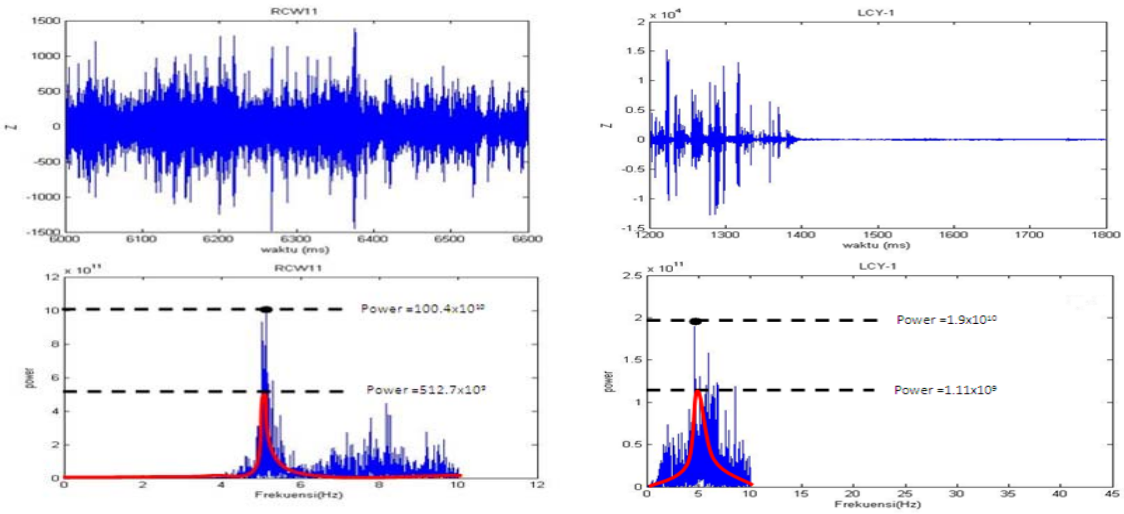

Figure 5 - Raw measurement data at the point of RCW 11 (left) and the Well LCY-1 (right) with a sampling rate of 100 Hz and a spectrum of anomalies Well LCY-1, processed using Software MATLAB2010.

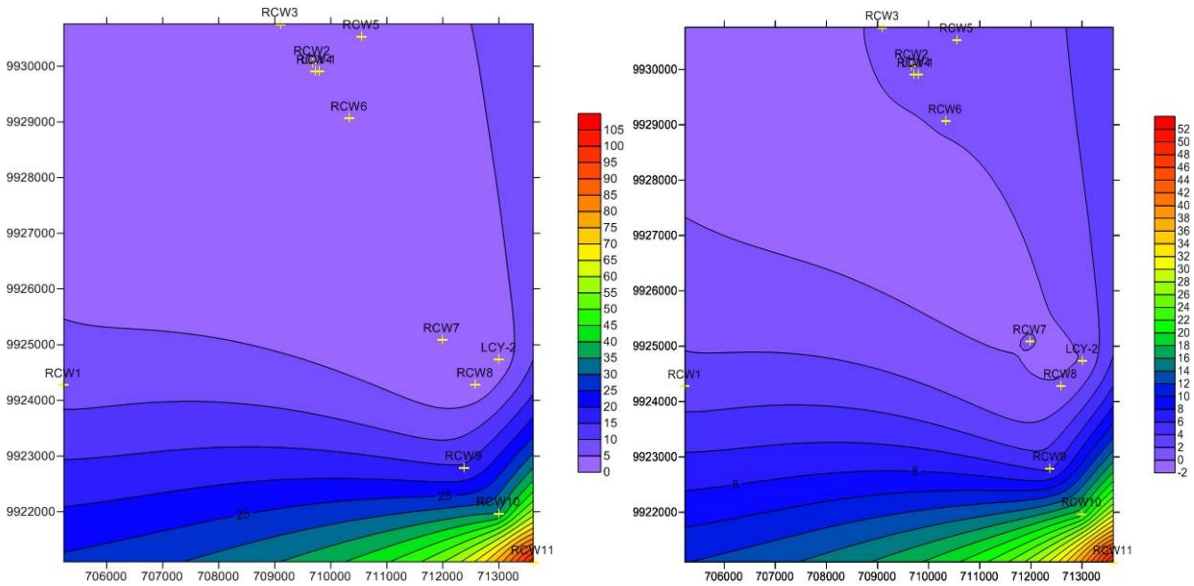

Figure 6 - Map of maximum spectrum anomaly (left) and average spectrum anomaly (right) frequency of 2 Hz - 6 Hz.

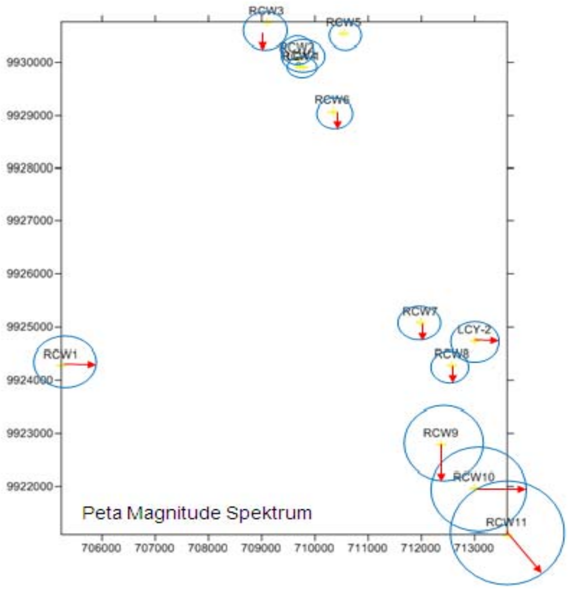

Figure 7 - Plot of magnitude microseismic frequency spectrum 2 - 6 Hz.

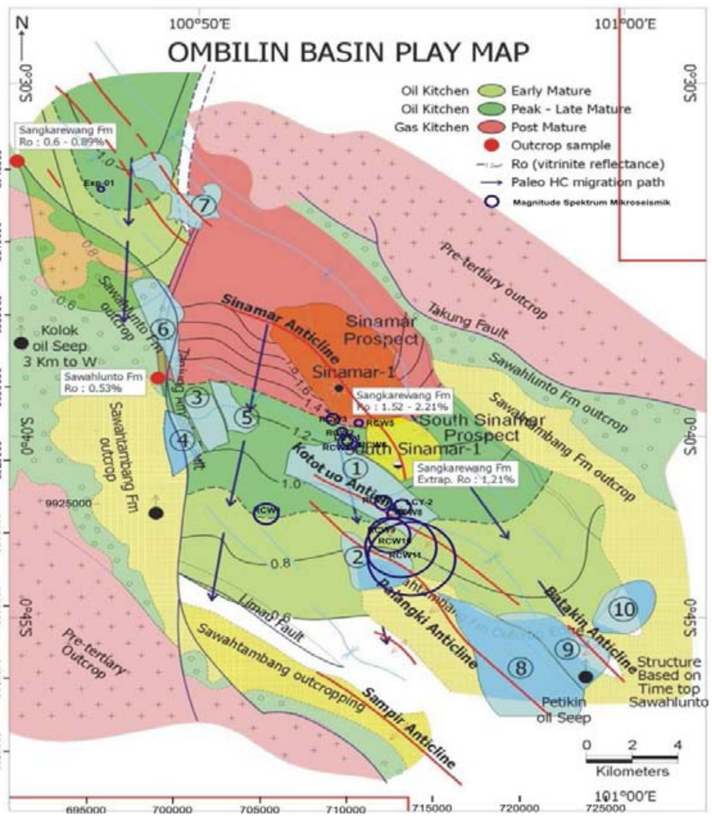

Figure 8 - Microseismic spectrum anomaly on frequency 2 – 6 Hz and the relationship with regional geology in research area (Sarkowi dkk, 2010).

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