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The Development of Non-Conventional Oil and Gas in Indonesia Case Study on Hydrocarbon Shale

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Abstract

Oil and gas fuel from unconventional types of reservoirs was the development of alternative sources in addition to oil and gas fuels from conventional type reservoirs that can be obtained to meet domestic needs. The development of unconventional oil and gas reservoirs has developed rapidly outside Indonesia, such as in North America and Canada. One type of unconventional oil and gas reservoir was obtained from shale rock reservoirs. Hydrocarbon shale produced from shale formations, both source from rock and reservoir. This unconventional hydrocarbon has a big potential to be utilized. In this study, an analysis of the development of unconventional oil and gas from Shale Hydrocarbons carried out in Indonesia. This research included the distribution of shale reservoir basins, the number of unconventional shale reservoir resources, factors affecting the development of unconventional oil and gas in shale reservoirs in Indonesia, efforts made by the government to promote exploration activities, exploitation of shale reservoirs in Indonesia, and existing regulations for non-conventional oil and gas. The development of unconventional oil and gas reservoir shale needed to be developed immediately and will attract investors to meet domestic needs for renewable energy needs. From the geological data obtained, there were 6 basins and 11 formations that analyzed for commercialization. Tanjung and BatuKelau Formation was a prospect formation from four desired data categories. In terms of regulation, it still needed improvement to increase the interest of upstream oil and gas entrepreneurs in the unconventional oil and gas shale reservoir. Research in the field of unconventional oil and gas exploitation technology for hydrocarbon shale needed to be improved.

INTRODUCTION

At present, up to 83% of the world's energy is dominated by fossil energy, this number certainly forces the oil and gas industry players to develop exploration and development of hydrocarbon resources, including one of the non-conventional hydrocarbon shale reservoirs as alternative energy sources. The development of oil and gas exploitation in Indonesia still relies on conventional hydrocarbons (Partowidagdo, 2009). According to Sosrowidjojo (2011), oil and gas exploration in the world has now changed direction from conventional oil and gas exploration to non-conventional. This is because the number of conventional oil and gas reserves has decreased dramatically, making us have to find new reserves which are certainly more difficult, so that requires new technology and thinking (Gunadi et al., 2013; Harsolumakso, 2001; Naser et al., 2018; Suranto, 2016). According to Sosrowidjojo (2011), shale gas is a gas obtained from broodstocks in the form of shale trapped in the source rock itself. Shale gas is

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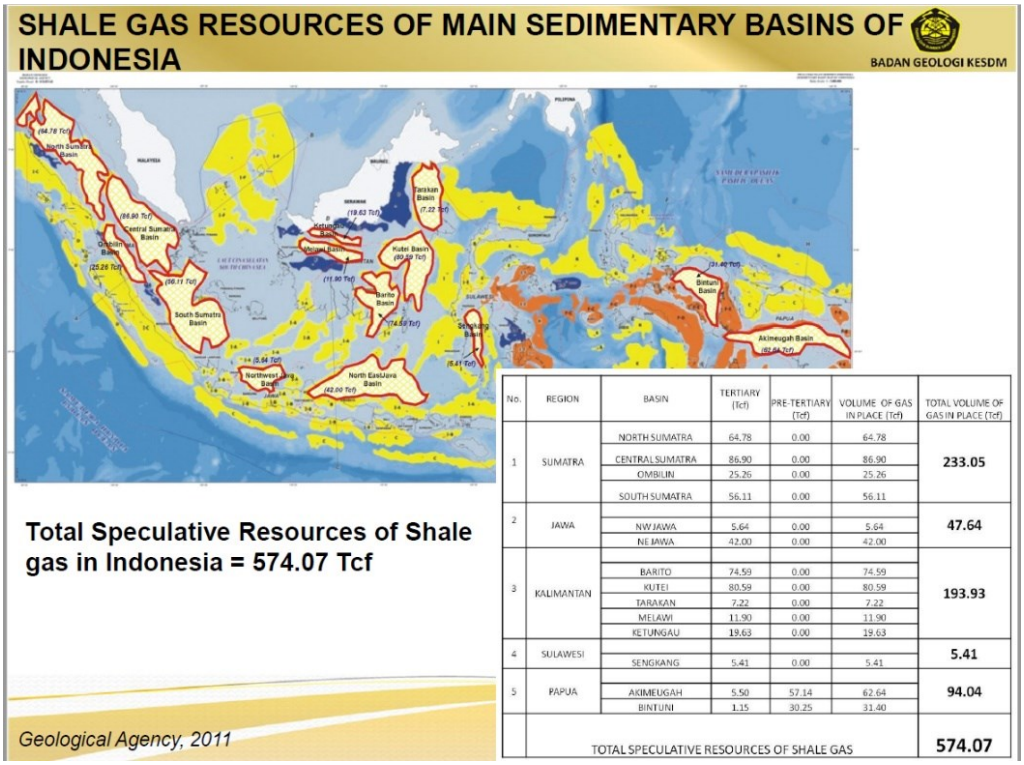
one of the unconventional gases that has twice the potential of conventional gas with a value of 500 BCFD (Bakshi et al., 2017). There is a need for studies that can provide information on the development of unconventional oil and gas from hydrocarbon shale including the distribution of shale reservoir basins, the amount of non-conventional shale hydrocarbon resources, and existing regulations for non-conventional oil and gas so that they can be developed immediately and attract investors to invest in unconventional oil and gas hydrocarbon shale.

This study aims to determine the extent to which unconventional oil and gas hydrocarbon shale are developing in Indonesia, what are the factors that influence the development of unconventional oil and gas shale reservoirs in Indonesia, and determine the prospects and efforts in the development of unconventional shale reservoirs in Indonesia.

Various data has been collected to provide meticulous evaluation towards the past, present, and the future state of unconventional oil and gas hydrocarbon shale exploration. The collective data is used to present an assesment of the several development situations of oil and gas hydrocarbon shale which include the analysis of shale hydrocarbon, the unconventional oil and gas government policies, and current utilization of shale hydrocarbon in Indonesia.

ANALYSIS OF SHALE HYDROCARBON FROM GEOLOGICAL DATA

Based on hydrocarbon shale basins data surveyed by the Geological Survey Center (Geology Agency, 2011), seven basins studied were the Central Sumatera basin, Bintuni Basin, Akimeugah Basin, Kutai Basin, Singkawang Basin, North Embaluh Basin, and Melawi Basin, and Ketungan Basin. The hydrocarbon shale basin in the region representing Sumatera was the Central Sumatera Basin, representing Kalimantan were the Barito basin, Kutai Basin, and Melawi Ketungau Basin, while the hydrocarbon shale basins in the Papua region were the Akimeugah Basin and Bintuni Basin (Figure 1). Chinn (1991) stated that the characteristics of commercial hydrocarbon were: the TOC content was more than 1%, in the gas generation period (Gas Window), the brittle mineral content was more than 48%, the effective thickness was above 30 meters if the bedding continuous flakes without interruption, and effective thickness above 50 meters if the shale coating was not continuous or has a TOC of less than 1%.



No.	REGION	BASIN	TERTIARY (Tcf)	PRE-TERTIARY (Tcf)	VOLUME OF GAS IN PLACE (Tcf)	TOTAL VOLUME OF GAS IN PLACE (Tcf)
1	SUMATRA	NORTH SUMATRA	64.78	0.00	64.78	233.05
		CENTRAL SUMATRA	86.90	0.00	86.90	
		OMBILIN	25.26	0.00	25.26	
		SOUTH SUMATRA	56.11	0.00	56.11	
2	JAWA					47.64
		NW JAWA	5.64	0.00	5.64	
		NE JAWA	42.00	0.00	42.00	
3	KALIMANTAN					193.93
		BARITO	74.59	0.00	74.59	
		KUTEI	80.59	0.00	80.59	
		TARAKAN	7.22	0.00	7.22	
		MELAWI	11.90	0.00	11.90	
		KETUNGAU	19.63	0.00	19.63	
4	SULAWESI					5.41
		SENGKANG	5.41	0.00	5.41	
5	PAPUA					94.04
		AKIMEUGAH	5.50	57.14	62.64	
		BINTUNI	1.15	30.25	31.40	
	TOTAL SPECULATIVE RESOURCES OF SHALE GAS					574.07

Figure 1. Map of Indonesian hydrocarbon shale (Source: Geology Agency, 2011).

Based on the data in Table 1, there were 5 basins and 11 formations suitable for the characteristics of commercial hydrocarbon shale. The Central Sumatera Basin had two formations which were Brown Shale Formation and Telisa Formation, the Akimeugah Basin had Piniyaa Formation and Kopai Formation, the Barito Basin had Tanjung formation, the Kutai Basin had Pamaluan Formation and Batu Kelau Formation, and the Ketungau Basin had Silat Formation and Ingar Formation.

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Table 1. Geological data of the hydrocarbon shale basin in Indonesia.

Unconventional Energy: Shale HC Reservoir Prospect in Indonesia							
Basin	Formation	TOC	Kerogen	Maturity	Quality	Brittlenes Index (BI)	Prospectivity
Central Sumatera	Brown Shales	2%	I-III	Early Mature-Oil Zone	Good - Excellent	<0,4	Not Prospect
Akimeugah	Telisa	>0,5%	II-III	Immature-Oil Zone	Poor - Excellent	-	Evaluate
	Piniyaa	2,28	II-III	Immature-Oil Zone		-	Evaluate
Bintuni	Kopai	3	II-III	Immature-Oil Zone	Poor-Good	-	Evaluate
	Piniyaa	2,28%	II-III	Immature-Oil Zone	Poor-Good	-	Evaluate
Barito	Kopai	3%	II-III	Immature-Oil Zone	Poor-Good	-	Evaluate
Kutai	Tanjung	0,16%-1,45%	II-III	Immature-Oil Zone	Poor-Good	0,6-0,82	Prospect
	Pamaluan	1,78%	III	Immature-Oil Zone	Fair – Good	<0,4	Not Prospect
Melawi Ketungau	Batu Kelau	1,06%	III	Immature-Gas Prone	Poor - Fair	0,57	Prospect
	Silat	1,55%	II-III	Early Mature	Fair – Good	-	Evaluate
	Ingar	0,55%	II-III	Early Mature-Oil Zone	Poor - Fair	-	Not Prospect
				Early Mature-Oil Zone	Poor - Fair		

Source: (Farizi, 2013; Geology Agency, 2011; Kusuma & Darin, 1989; Radityo et al., 2019; Santy & Panggabean, 2013; Sosrowidjojo, 2011; Sukhyar & Fakhruddin, 2013; Sutjipto, 1991; Zajuli & Wahyudiono, 2018)

From the TOC data, Table 2 can be seen as follows:

Table 2. Resource of organic material.

TOC (% wt)	Quality (Waples, 1985))	Quality (Peters & Cassa, 1994)
<0.5	Poor	Poor
0.5-1	Fair	Fair
1-2	Good	Good
2-4	Very Good	Very Good
>4	Excellent	Excellent

So that it refers Table 1 Shale Hydrocarbon data available in Indonesia, an analysis can be taken that:

Table 3. Resource of organic hydrocarbon shale material in Indonesia.

Basin	Formation	Toc	Quality
Central Sumatera	Brown Shales	2%	Good
	Telisa	>0,5%	Fair
Akimeugah	Kopai	3%	Very Good
	Piniyaa	2,28%	Very Good
Bintuni	Kopai	3%	Very Good
	Piniya	2,28%	Very Good
Barito	Tanjung	0,16% - 1,45%	Good
Kutai	Pamaluan	1,78%	Good
	Batu Kelau	1,06%	Good

Melawi Ketungau	Silat	1,55%	Good
	Ingar	0,55%	Fair

Source: (Farizi, 2013; Geology Agency, 2011; Haris et al., 2018; Kusuma & Darin, 1989; Radityo et al., 2019; Santy & Panggabean, 2013; Awang H. Satyana et al., 2007; Awang Harun Satyana, 2017; Sukhyar & Fakhruddin, 2013; Sutjipto, 1991; Zajuli & Wahyudiono, 2018)

Table 3 showed all formations were in the range from fair to very good. From the Kerogen data, it can be concluded that range III or gas window was the formation with the highest commercial value. It was accepted that the Pamaluan Frmation and Batu Kelau Formation had the greatest prospect.From the maturity data, four formations can be categorized as mature, among others, the formation of Brown Shale Formation, Batu Kelat Formation, Silau Formation, and Ingar Formation.From the quality, all formations can be categorized as commercial.

From the BI data collected, only the Barito and Batu Kelau formations can be categorized as commercial formations. Meanwhile, the other formations cannot be known so it can be concluded that the formation that fulfills the 4 conditions as a formation can be commercialized between another Barito and Batu Kelau.

ANALYSIS OF UNCONVENTIONAL OIL AND GAS POLICIES

The current policies governing upstream oil and gas business in the unconventional oil and gas sector include the Minister of Energy and Mineral Resources Regulation No. 38 of 2015 concerning the acceleration of non-conventional oil and gas exploitation. This policy has been revoked and replaced with Minister of Energy and Mineral Resources Regulation no. 08 year 2017 concerning gross split profit-sharing contracts, and Minister of Energy and Mineral Resources Regulation no. 52 year 2017 concerning the revision of the rules for gross split revenue sharing, and Per Minister no. 05 year 2012 concerning Procedures for determining and offering non-conventional oil and gas working areas.

With the Minister of Energy and Mineral Resources Regulation concerning the acceleration of unconventional oil and gas exploitation, the government has begun to concentrate on non-conventional oil and gas-related policies that provide contractors with discretion in determining the production-sharing system, which was sliding scale production sharing contract or gross split sliding scale production sharing contract. This Ministerial Regulation had been revoked in 2017 and replaced with Minister of Energy and Mineral Resources Regulation No. 8 year 2017 concerning gross split revenue-sharing contracts. Since that year, all non-conventional oil and gas companies referred to gross split production sharing contracts. The contract between conventional oil and non-conventional oil and gas had the same thing, but the article section of unconventional oil and gas business had an additional split of 16% for the contractor. The regulations for upstream non-oil and gas exploitation still needed to be developed and reviewed because the auction of unconventional oil and gas working areas, especially hydrocarbon shale, was still very far in number compared to the others. This required improved regulations that can attract upstream oil and gas entrepreneurs to invest in unconventional oil and gas. On the other hand, non-conventional oil and gas operational costs were far greater than conventional oil and gas, so there needs to be a split change obtained and also contractors who were allowed to take part in the auction. Because the location of many hydrocarbon shales was below the depth of conventional oil and gas, there should be a regulation that allows drilling in the same well in conventional oil and gas. Of course, this could minimize exploration costs. Studies are needed to provide incentives for entrepreneurs who have explored but cannot find hydrocarbons in shale hydrocarbons.

EXPLOITATION OF SHALE HYDROCARBONS INDONESIA

At present, the exploitation of hydrocarbon shale in Indonesia has only reached the exploration stage. Table 4 detailed 5 contractors were participating in the auction of non-conventional oil and gas working areas, including:

Table 4. Non-conventional oil and gas work areas in Indonesia

No.	Name	Operator	Contract sign date
1	MNK Central Bangkanai	PT. Adaco Energy	May 25th, 2016
2	MNK Kisaran	Pacific Oil and Gas (MNK Kisaran) Limited	May 22th, 2015
3	MNK Palmerah	Bukit Energy Resources Palmerah Deep Pte. Ltd.	May 25th, 2015
4	MNK Sakakemang	Bukit Energy Resources Sakakemang Deep Pte. Ltd.	May 25th, 2015
5	MNK Selat Panjang	Petroselat NC Ltd.	May 25th, 2015

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6	MNK Subagut	PT. Pertamina Hulu Energy MNK Sumatera Utara	May 25th, 2013

Source: (Survey from Directorate of Oil and Gas Upstream Development , 2019).

To be sure, the lack of exploration technology development in Indonesia had hampered the development of unconventional oil and gas in Indonesia. However, this was not a major obstacle because we can conduct a comparative study with countries that had successfully developed non-conventional oil and gas shale hydrocarbons, especially such as the US and Canada(Carpenter, 2014; Nurhandoko, 2013; Permana, 2015). The success of developing hydrocarbon shale oil and gas can reduce the price of petroleum. For this reason, the government needed to develop large-scale research for hydrocarbon shale in Indonesia so that its development and success could be faster and covered the shortage of oil supply from conventional oil and gas in the coming years. Based on existing references, the success of the development of non-conventional oil and gas hydrocarbon shale in the US and Canada was the discovery of hydraulic fracturing or fracking technology combined with horizontal drilling(Akbar, 2015; Arif, 2015). The purpose of hydraulic fracturing was to inject high-pressure fluid and propane into shale formations to increase production. This method increased the permeability of hydrocarbon shale. Hydrocarbon shale was a type of rock that had a shaft but a small permeability. To overcome this, the government should conduct research, study and pilot projects on the technology on the characteristics of hydrocarbon shale reservoirs in Indonesia.

CONCLUSIONS

The results of geological data analysis in the form of TOC, Kerogen, maturity, quality, and Brittleness Index data showed that the characteristics of hydrocarbon shale that have commercial characteristics were from the Sumateran Basin, Akimeugah Basin, Bintuni Basin, Barito Basin, Kutai Basin, and Melawi Ketungau Basin. The prospective formations were the Tanjung Formation of the Barito Basin and Batu Kelau Formation from the Kutai Basin. Meanwhile, non-prospective formations were the Brown Shale Formation of the Central Sumatera Basin, the Pamaluan Formation of the Kutai Basin, and the Ingar Formation of the Melawi Ketungau Basin. Meanwhile, for the Telisa Formation from the Central Sumatera Basin, the Piniyaa Formation and the Kopai Formation from the Akimeugah Basin, the Piniya and Kopai Formations from the Bintuni Basin, and the Silat Formation from the Melawi Ketungai Basin still needed to be re-evaluated due to unknown Brittleness Index data. The potential of shale hydrocarbons Indonesia mainly in marine sediment formations with several of non-marine sediment formations as coal shale deposits in both Tertiary and Pre-Tertiary ages. The policy of governing upstream oil and gas exploitation in the unconventional oil and gas sector already existed but needed to be developed and improved to accelerate the upstream oil and gas exploitation in the unconventional oil and gas sector. Upstream oil and gas exploitation in the unconventional oil and gas sector required to study and research its success. At present, the exploitation of hydrocarbon shale hydrocarbons had not yet developed and has only reached the exploration stage. The government needed to follow up so that non-conventional oil and gas policies, especially hydrocarbon shale, were immediately followed up so that the upstream oil and gas shale hydrocarbon exploitation will soon develop as one of the supports for energy needs in Indonesia.

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REFERENCES

Akbar, M. I. (2015). *Analisa Sensitivitas Hydraulic Fracturing pada Reservoir Tight Gas Sand Terhadap Penentuan Gas In-Place dengan Uji Pressure Drawdown dan Recovery Factor*. Institut Teknologi Bandung.

Arif, A. (2015). *Analisis dan Strategi Pola Sumur Produksi pada Reservoir Datar Coalbed Methane (CBM) Terhadap Komukasi Aquifer*. Institut Teknologi Bandung.

Bakshi, V., Fulford, N., Pereira, R., Davies, J., Delic, S., Morrissey, J., Anderson, S., Darowski, M., Lillie, A., Titus, E., Failat, Y. A., Bassett, R. A., Eacott, S., Fan, B., & Dutton, J. (2017). *Shale Gas: A Practitioner's Guide to Shale Gas and Other Unconventional Resources* (V. Bakshi (ed.); 2nd Editio). Globe Law and Business Limited.

Carpenter, C. (2014). Unconventional-Reservoir Development in Mexico. *Journal of Petroleum Technology*, *66*(07), 122–126. https://doi.org/10.2118/0714-0122-jpt

Chinn, E. W. (1991). The Role of Organic Geochemistry in Petroleum Exploration. *Basin Research Institute Bulletin*, 15–23.

Farizi, F. (2013). Analisis Potensi Shalegas Formasi Tanjung Cekungan Barito, Kalimantan Selatan Menggunakan Data Petrografi, SEM, Geokimia, XRD, dan Seismik 2D. *Geological Engineering E-Journal*, *5*(1), 74–83.

Geology Agency, G. agency. (2011). *Karakterisasi Batuan Shale Reservoir Hidrokarbon Untuk Eksplorasi Migas Indonesia*.

Gunadi, T., Bae, W., Lee, J., Hidayat, F., Netzhanova, A., Suranto, A. M., Lee, J., Hidayat, F., & Netzhanova, A. (2013). Revitalizing Indonesia's Potential for Oil Production : The Study of Electromagnetically Heated Gravel Packs for Steam-produced Heavy Oil Reservoirs. *Society of Petroleum Engineers - SPE Heavy Oil Conference Canada 2013*, *2*(June), 1–12.

Haris, A., Hutagalung, A., & Riyanto, A. (2018). Geochemical and Petrophysical Assessment of Telisa Shale Gas Reservoir: A Case Study From South Sumatra Basin, Indonesia. *International Journal of GEOMATE*, *15*(52), 199–205. https://doi.org/10.21660/2018.52.63389

Harsolumakso, A. H. (2001). *Geologi Untuk Perminyakan*. ITB.

Kusuma, I., & Darin, T. (1989). The Hydrocarbon Potential of the Lower Tanjung Formation, Barito Basin, S.E. Kalimantan. *18th Annual Convention Proceedings*, 107–138.

Naser, M. A., Erhayem, M., Hegaig, A., Abdullah, H. J., Amer, M. Y., & Mohamed, A. A. (2018). Comparative Study of Using Sea-Water for Enhanced Oil Recovery in Carbonate and Sandstone Reservoirs: Effects of Temperature and Aging Time on Oil Recovery. *Journal of Earth Energy Engineering*, *7*(2), 1–13. https://doi.org/10.25299/jeee.2018.vol7(2).2126

Nurhandoko, B. E. B. (2013). Shale Gas Reservoir Characterization Strategy. *HAGI-IAGI Joint Convention Medan*.

Partowidagdo, W. (2009). *Migas dan energi di Indonesia: permasalahan dan analisis kebijakan* . Development Studies Foundation.

Permana, A. K. (2015). *Shale Hydrocarbon Characterization: A Case Study of Shales From The Brown Shale and Telisa Formation, Central Sumatera Basin, Indonesia*.

Peters, K. E., & Cassa, M. R. (1994). Applied Source Rock Geochemistry. In L. B. Magoon & W. G. Dow (Eds.), *The Petroleum System—From Source to Trap* (pp. 93–120). American Association of Petroleum Geologists. https://doi.org/10.1306/m60585c5

Radityo, D., Sapiie, B., & Iskandar, Y. (2019). Studi Geomekanika dan Nilai Kegetasan Untuk Evaluasi Potensi Gas Serpih Formasi Batu Kelau Cekungan Kutai. *Bulltetin of Geology*, *3*(1), 300–319. https://doi.org/10.5614/bull.geol.2019.3.1.4

Santy, L. D., & Panggabean, H. (2013). The Potential of Ketungau and Silat Shales in Ketungau and Melawi Basins, West Kalimantan: For Oil Shale and Shale Gas Exploration. *Indonesian Journal on Geoscience*, *8*(1), 39–53. https://doi.org/10.17014/IJOG.8.1.39-53

Satyana, Awang H., Marpaung, L. P., Purwaningsih, M. E. M., & Utama, M. K. (2007, May). Regional Gas Geochemistry of Indonesia: Genetic Characterization and Habitat of Natural Gases. *31st Annual Convention Proceedings*.

Satyana, Awang Harun. (2017, May). Regional Petroleum Geochemistry of Indonesian Basins: Updated, and Implications for Future Exploration. *41st Annual Convention & Exhibition*.

Sosrowidjojo, I. B. (2011). Organic Geochemistry: 1. Geographic Location of Crude Oils Based on Biomarker Compositions of the Sunda-Asri Basins, Indonesia. *International Journal of the Physical Sciences*, *6*(31), 7291–7301. https://doi.org/10.5897/IJPS11.041

Sukhyar, R., & Fakhruddin, R. (2013). *Unconventional Oil and Gas Potential in Indonesia with Special Attention to Shale Gas and Coal-Bed Methane*.

Suranto, A. M. (2016). Perbandingan Kinerja Reservoir Gas Konvensional dengan Coal Bed Methane (CBM). *Journal of Earth Energy Engineering*, *5*(1), 1–10. https://doi.org/10.22549/jeee.v5i1.461

Sutjipto, R. (1991). Sedimentology of the Melawi and Kentungau Basins, West Kalimantan, Indonesia. In *University of Wollongong Thesis Collection 1954-2016*. University of Wollingong.

Waples, D. W. (1985). *Geochemistry in Petroleum Exploration* (1st ed.). Springer Netherlands.

Zajuli, M. H. H., & Wahyudiono, J. (2018). Rock-Eval Pyrolysis of the Oligocene Fine-grained Sedimentary Rocks from the Pamaluan Formation, Gunung Bayan Area, West Kutai Basin, East Kalimantan : Implication for Hydrocarbon Source Rock Potential. *Jurnal Geologi Dan Sumberdaya Mineral*, *19*(2), 73–82. https://doi.org/10.33332/jgsm.geologi.19.2.73-82