Journal of Technomaterial Physics
Journal homepage: https://talenta.usu.ac.id/JoTP

Delineation of Coal Identification Using Inversion Microtremor and Borehole at PT X

Nurul Ilmi Rahmawati[1], Refrizon[1]*, Budi Praba Kusuma[2], Andre Rahmat Al Ansory[1], M. Taufiqqurahman Syah[1], Della Cici Anggria[1], and Olga Triutami[1]
[1]*Geophysic Study Program, University of Bengkulu, Bengkulu, 38122, Indonesia*
[2]*PT. Cakrawala Dinamika Energi, Bengkulu*
*Corresponding Author: refrizon@unib.ac.id

ARTICLE INFO

Article history:
Received 5 February 2024
Revised 12 February 2024
Accepted 19 February 2024
Available online 29 February 2024

E-ISSN: 2656-0755
P-ISSN: 2656-0747

How to cite:
N. I. Rahmawati, Refrizon, B. P. Kusuma, A. R. A. Ansory, M. T. Syah, et al., " Delineation of Coal Identification Using Inversion Microtremor and Borehole at PT X," Journal of Technomaterial Physics, vol. 06, no. 01, pp. 62-68, Feb. 2024, doi: 10.32734/jotp.v6i1.16077.

ABSTRACT

Coal is a natural resource composed of organic and inorganic materials. The potential of coal is one of the national and world resources. Microtremor method is a geophysical exploration method that utilises microseismic waves to identify the presence of hydrocarbons. Microtremor data processing is processed first using Geopsy software to obtain the H/V curve which will then be processed using Hv-Inv software to obtain the Vs value. Microtremor data is correlated with data from the borehole, the coal seam thickens to the southwest. Similarly, with the correlation results of other microtremor cross sections, the cross section shows that the coal seam is thickened and continuous to the west or southwest. This is further strengthened by the existence of boreholes as a correlation of coal Vs value data in the range of 613.37 m/s-887.70 m/s. Other constituent materials such as soil, claystone, sandstone, carboneseus. Based on the Vs value of the 1D model, it is known that the research area shows the distribution of coal at a depth of 53.5-76 metres. The coal layer in the study area is bituminous to sub-bituminous coal.

Keywords: Coal, Inversion, Microtremor, Vp, Vs

ABSTRAK

Batubara merupakan sumber daya alam yang tersusun dari bahan organik dan anorganik. Potensi batubara yang merupakan salah satu sumber daya nasional maupun dunia. Eksplorasi pendahuluan juga seringkali dilakukan dengan menggunakan metode Geofisika.metode Mikrotremor merupakan metode eksplorasi geofisika yang memanfaatkan gelombang mikroseismik untuk mengidentifikasi keberadaan hidrokarbon, Pengolahan data mikrotremor diolah terlebih dahulu dengan menggunakan Software Geopsy. untuk mendapatkan kurva H/V yang selanjutnya akan diolah dengan menggunakan software Hv-Inv untuk mendapatkan nilai Vs. Data mikrotremor dikorelasikan dengan data dari borehole, lapisan batubara mengalami penebalan ke arah barat daya. Begitu pula dngan hasil korelasi penampang mikrotremor yang lainnya, pada penampang tersebut menunjukkan bahwa lapisan batubara menebal dan menerus ke arah barat atau barat daya. Hal itu diperkuat lagi dengan adanya borehole sebagai korelasi data nilai Vs batubara terdapat pada range 613,37 m/s–887,70 m/s. Material penyusun lain seperti soil, claystone, sandstone, carboneseus. Berdasarkan nilai Vs dari model 1D diketahui bahwa daerah penelitian menunjukkan adanya sebaran batubara pada kedalaman 53,5-76 meter. Lapisan batubara yang ada di daerah penelitian merupakan batubara kelas bituminous sampai sub-bituminus.

Kata kunci: Batubara, Inversi, Mikrotremor, Vp, Vs

1. Introduction

Indonesia is one of the countries with the highest level of fuel oil consumption in the world. The increase in fuel oil energy consumption is not matched by depleting petroleum reserves. This has prompted the government to search for new energy sources to ensure energy security in the future. Coal exploration is the

right choice because it still holds great potential for mining [1]. The potential of coal, which is one of the national and world resources, excessive use causes the amount of reserves to decrease, therefore exploration of new areas to answer industrial challenges is needed and of course the technology used is environmentally friendly [2].

Coal is one type of natural resource that is composed of organic and inorganic materials. The content of this organic material comes from plant remains that undergo various decomposition and changes in physical and chemical properties, both before and after being covered by overlying deposits. Inorganic materials consist of various kinds of minerals, especially clay minerals, carbonates, silicates and various other minerals that are less in number [3]. As an energy source, coal is able to produce high enough calories/heat, which is between 5,000 to 9,000 calories per gram [4].

Coal can be utilized in solid form (lump coal or briquettes), liquid form (coal oil and coal water fuel), and gas form (coal gas synthesis). Before the discovery of oil and gas reserves in the 19th century, coal was the world's main primary energy source. Its role in the industrial revolution in the 18th century was huge, especially with the invention of the steam engine [5].

Coal resources can be identified by conducting exploration activities. Preliminary exploration is also often carried out using Geophysical methods. Geophysical method is one of the branches of physics that studies the earth based on physical concepts. In general, geophysical methods are divided into two categories, namely passive and active methods. Geophysical surveys that are often used include magnetic, gravity, geoelectric, electromagnetic and seismic methods. Currently, the passive seismic method is relatively new for hydrocarbon identification when compared to active seismic. Passive seismic is a geophysical exploration method that utilizes microseismic waves to identify the presence of hydrocarbons, one of the passive seismic methods that can be used for preliminary exploration is the microtremor method.

Microtremor method or commonly referred to as ambient noise is a ground vibration that can describe the condition of the area and is generated by natural or artificial events, such as wind, ocean waves or vehicle vibrations [6]. Waves generated by human activities such as waves caused by cars, motorcycles, trains have short periods. Waves generated by wind, storms and ocean waves have long periods (2-3 seconds or more) [7]. Microtremor analysis is more suitable because it is more environmentally friendly and simple [8].

In recent years, microtremor exploration has achieved results in the field of cave exploration, for example, Ma Guosong (2022) applied the microtremor method for water-rich exploration for the first time. Coal identification research has also been conducted by [9] Nanling in Taiyuan City. The microtremor method only requires about 20-30 minutes of recording time to determine the soil characteristics based on the dominant frequency (f_0) and amplification factor (A_0) parameters [10] and can determine the shear wave velocity (Vs) of the coal itself because every material has a shear wave velocity (Vs) value that varies with the type of material.

2. Method

2.1. Research Locations

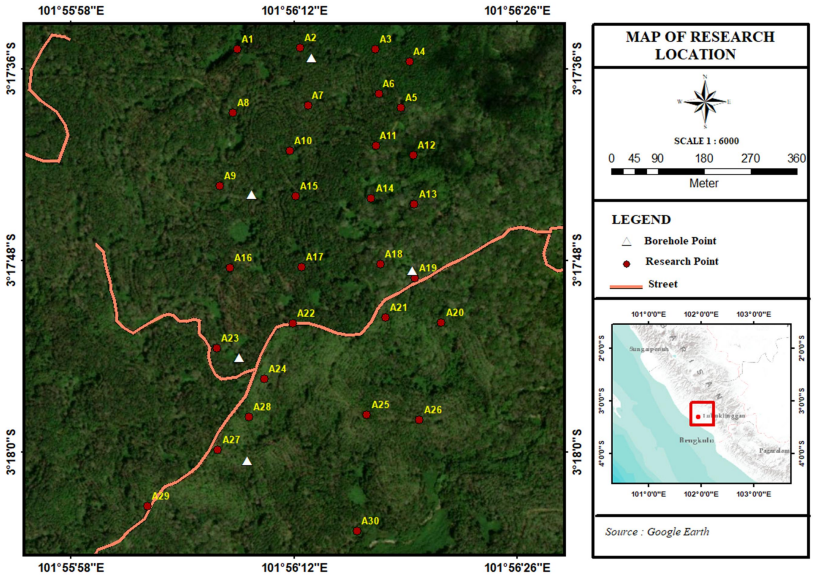

Figure 1. Research location points.

This research was conducted at PT X using 30 measurement points. Regionally, the research area belongs to the Lemau Formation and Bintunan Formation which are composed of sandstone, mudstone, siltstone, coal and conglomerate of Middle to Upper Miocene age [11].

2.2. Materials

This research uses the microtremor method. The tools and materials used in this research are: a set of Portable Short Period Seismometer Gemini 2 Sn-1405 model to record ground vibrations, geological compass, GPS, camera, laptop and software such as Geopsy Software, Arcgis, Hv-Inv Software, Microsoft Excel, and Coreldraw.

2.3. Processing Microtremor data with geopsy

Microtremor data processing is processed first using Geopsy software. Processing is done by inputting microtremor recording data on the import signal. Next, smoothing and windowing are carried out to obtain the results of the H/V curve in the form of the dominant frequency (f_0) and the peak value of the amplification factor (A_0). The H/V curve must be in accordance with SESAME (2004) validation and then save it in *txt format.

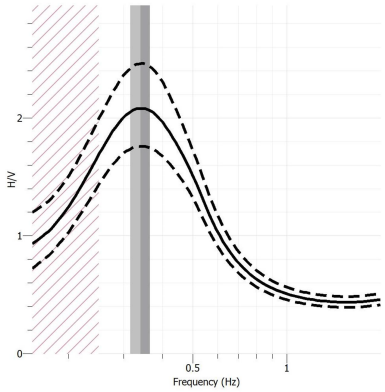

Figure 2. H/V curve processing results at point A1.

The horizontal axis is the dominant frequency value (f_0) and the vertical axis the amplification (A_0). The dashed line is the deviation of the curve, while the thick black line is the H/V curve. The dominant frequency is the result of the interpretation of the H/V curve.

2.4. Data Processing with Hv-Inv

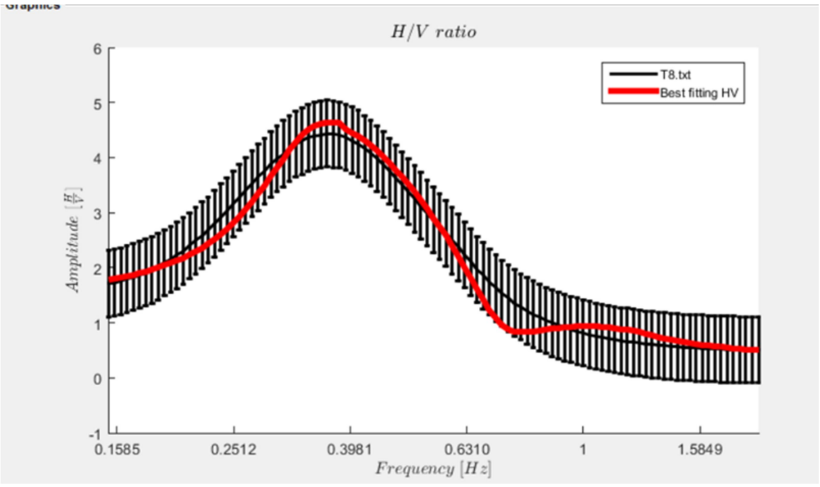

Figure 3. H/V inversion result curve at study point 8.

Microtremor data that have obtained frequency and amplification value curves are then inputted into the Hv-Inv software in the form of processed data results. The HV-Inv application is a MATLAB-based computer application developed by García-Jerez et al. that is used to analyze and model subsurface structures using the Monte Carlo (MC) principle [12]. Furthermore, it is analyzed using Monte Carlo simulation in order to obtain the most suitable curve. The curve is said to be suitable if the misfit value obtained is small and the H/V graph coincides. In data processing with Hv-Inv, the parameters of thickness, shear wave velocity, compressive wave velocity, and density are obtained [13].

3. Results and Discussion

This research uses the microtremor passive seismic method at the PT X location. Regionally, the study area belongs to the Lemau formation which is dated around middle Miocene to late Miocene which is a coal-bearing formation.

Shear wave velocity is an important parameter in interpreting the subsurface conditions of an area [14]. Vs is also a direct indicator of soil stiffness and strength, where the greater the shear wave velocity, the greater the hardness of the soil or rock.

Table 1. Shear wave velocity value.

Material type	Shear wave velocity (m/s)
Soft mud	<200
Dried sand	300-600
Wet sands	700-900
Clay	500-800
Land	1000-1200
Sandstone	1600-2600
Shale	2200-2400
Limestone	2500-3100
Granite	3200-3800
Basalt	3400-4000

According to Posgay (1967), the compressive wave velocity (Vp) of coal is 1600-1900 m/s. Meanwhile, in this study, the shear wave velocity (Vs) is used. Meanwhile, Shear wave speed (Vs) is half the speed of the compressive wave speed (Vp) It can be concluded that the shear wave speed (Vs) of coal is 800-950 m/s. There are several factors that affect the speed of waves in the coal layer, including the modulus of elasticity and the type of coal, anthracite coal is a type of coal that has the highest wave speed among other types of coal. This is also supported by research from Ibrahim et al. that anthracite has the highest shear wave speed, which means that anthracite coal is very dense and not easily broken [15].

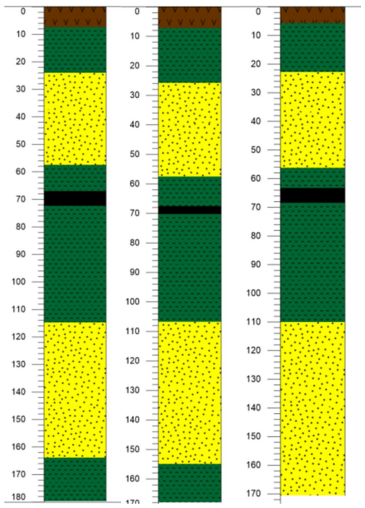

Figure 4. 1D stratigraphic results at points 27, 28, 29 respectively.

Figure 4 above shows that the types of constituent materials in the research area are dominated by soil, claystone, sandstone, and coal based on the shear wave velocity values that propagate in the research area. According to the results of the 1D stratigraphic interpretation of microtremor data in the research area, it is known that the Vs value of the coal layer is in the range of 613.37 m/s - 887.70 m/s with various types of coal and different water content. From the shear wave velocity, it is estimated that the type of coal seam in the research area is bituminous or sub-bituminous. The inversion results show variations in coal depth at each research point that are influenced by different shear wave velocities (Vs). However, the depths are not significantly different from each other.

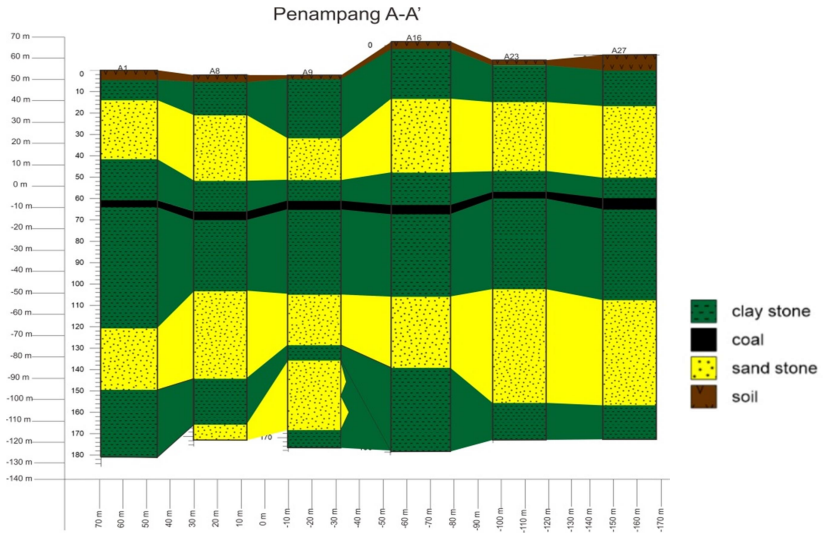

Figure 5. cross section A that intersects the study point vertically from north to south.

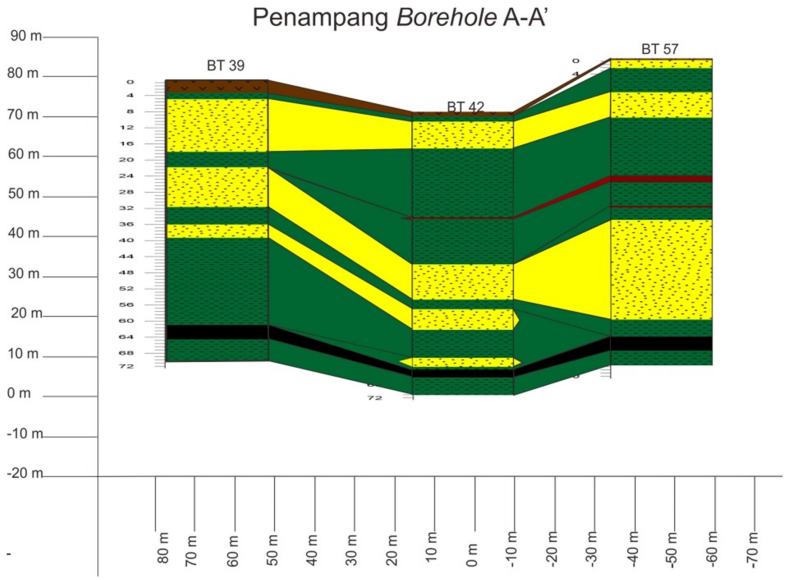

Figure 6. Cross-sections of three boreholes near the study point.

Based on the interpretation results between 2D stratigraphy of microtremor data and borehole data, it is known that there are differences in the thickness and top coal of the coal layer. Likewise with other research points, the depth and thickness of the coal seam is slightly different from the data from the borehole, but the difference is not too significant. After the microtremor data is correlated with data from the borehole, it can be seen that in cross section E-E' the coal seam thickens to the southwest. Similarly, with the correlation

results of other microtremor cross sections, the cross section shows that the coal layer is thickened and continuous to the west or southwest. This is reinforced by the existence of boreholes as data correlation.

The coal seams at this research point are bituminous to sub-bituminous coal seams that are prospective for mining, so the microtremor method is suitable for conducting initial exploration of coal estimation. Heryanto and Suyoko mentioned that in the Sebayur area there are three coal layers that can be found in the Lemau Formation [16]. However, microtremor measurements can only identify coal in the first layer. Therefore, it is necessary to explore coal in the same location as this research using other geophysical methods so that it can be correlated and validated.

4. Conclusion

Based on the interpretation between 1D stratigraphy and borehole, it is known that the Vs value of coal is in the range of 613.37 m/s - 887.70 m/s with various types of coal and different water content. There are other constituent materials found in the research area such as soil, claystone, sandstone, carboneseus. Based on the Vs value of the 1D model, it is known that the research area shows the distribution of coal at a depth of 53.5-76 meters. The coal layers in the study area are estimated to be bituminous to sub-bituminous coal layers. After correlation with the borehole, it is known that the distribution of coal seams spreads and is continuous to the West or Southwest. The accuracy of the microtremor method is less when compared to the borehole, but the microtremor method can be used as a preliminary survey in determining the presence of coal seams.

Acknowledgments

There is nothing that the author can give other than the greatest gratitude to Bengkulu University.

References

[1] S. S. Siregar, I. Sota, and J. Julkipli, “Interpretasi Sebaran Batubara Berdasarkan Data Well Logging Di Daerah Blok X Pulau Laut Tengah Kabupaten Kotabaru,” *J. Fis. Flux J. Ilm. Fis. FMIPA Univ. Lambung Mangkurat*, vol. 12, no. 1, pp. 43–53, 2015.

[2] T. Ngaderman and L. Reliubun, “Eksplorasi Dan Potensi Sumber Daya Batubara Daerah Sabeyap Kecil, Kabupaten Jayapura, Provinsi Papua,” *J. Median Arsit. dan Planol.*, vol. 11, no. 1, pp. 1–4, 2021, doi: 10.58839/jmap.v11i1.866.

[3] I. L. Resta and R. Novrianti, “Identifikasi Lapisan Batubara Menggunakan Metode Geolistrik Konfigurasi Schlumberger Di Lapangan X Kecamatan Bulian Kabupaten Batanghari,” *J. Online Phys.*, vol. 8, no. 2, pp. 82–89, 2023, doi: 10.22437/jop.v8i2.23979.

[4] Sutarno, *Sumberdaya Energi*. Yogyakarta: Graha Ilmu, 2013.

[5] Pasymi, *Batubara (Jilid 1)*. Padang: Bung Hatta University Press, 2008.

[6] H. Arai and K. Tokimatsu, “S-wave velocity profiling by joint inversion of microtremor dispersion curve and horizontal-to-vertical (H/V) spectrum,” *Bull. Seismol. Soc. Am.*, vol. 95, no. 5, pp. 1766–1778, 2005, doi: 10.1785/0120040243.

[7] Y. Nakamura, “Method for dynamic characteristics estimation of subsurface using microtremor on the ground surface,” *Q. Rep. RTRI (railw. Tech. Res. Institute)*, vol. 30, no. 1, 1989.

[8] Aslam, S. Aswad, and M. Fawzy Ismullah, “Mikrozonasi Seismisitas Wilayah Makassar Dan Sekitarnya Berdasarkan Data Mikrotremor Dan Data Spt (Standard Penetration Test),” *J. Unila*, pp. 1–15, 2019.

[9] C. Yu, Z. Wang, and M. Tang, “Application of Microtremor Survey Technology in a Coal Mine Goaf,” *Appl. Sci.*, vol. 13, no. 1, 2023, doi: 10.3390/app13010466.

[10] V. Arintalofa, G. Yulianto, and U. Harmoko, “Analisa Mikrotremor Menggunakan Metode HVSR untuk Mengetahui Karakteristik Bawah Permukaan Manifestasi Panas Bumi Diwak dan Derekan Berdasarkan Nilai Vp,” *J. Energi Baru dan Terbarukan*, vol. 1, no. 2, pp. 54–61, 2020, doi: 10.14710/jebt.2020.9276.

[11] S. Gafoer, T. C. Amin, R. Pardede, and P. P. dan Pengembangan Geologi, “Geologi lembar Bengkulu, Sumatera = The geology of the Bengkulu quadrangle, Sumatera,” 1992. [Online]. Available: https://api.semanticscholar.org/CorpusID:127540666

[12] A. García-Jerez, J. Piña-Flores, F. J. Sánchez-Sesma, F. Luzón, and M. Perton, “A computer code for forward calculation and inversion of the H/V spectral ratio under the diffuse field assumption,” *Comput. Geosci.*, vol. 97, pp. 67–78, 2016, doi: 10.1016/j.cageo.2016.06.016.

[13] D. Gustiparani, "Identifikasi Kedalaman Batuan Dasar di Kecamatan Sungai Serut dan Teluk Segara Kota Bengkulu Menggunakan Pendekatan Kecepatan Gelombang Geser (Vs)," Universitas Bengkulu,

2021.
[14] J. Milsom and A. Eriksen, *Field Geophysics*. John Wiley & Sons, Ltd, 2011.
[15] Sutopo, E. Ibrahim, N. Kurniawati, and F. Lasmana, “Studi Modulus Elastisitas (Modulus Young) untuk Karakterisasi Berbagai Jenis Batubara Berdasarkan Analisis Kecepatan Gelombang,” *J. Penelit. Sains,* vol. 12, no. 2(B), p. 12203, 2009, doi: 10.21512/comtech.v3i2.2331
[16] R. Heryanto and Suyoko, “Karakteristik batubara di Cekungan Bengkulu," *J. Geol. Indones.,* vol. 2, no. 4, pp. 247–259, 2007, doi: 10.17014/ijog.vol2no4.20075.