INDONESIAN MINING JOURNAL Vol. 18, No. 3, October 2015 : 109 - 120

ASSESSMENT FOR DATA CORRELATION OF THE DOWNHOLE SEISMIC MEASUREMENT RESULTS ON UNDERGROUND COAL GASIFICATION LOCATION USING MULTIVARIATE ANALYSIS

PENILAIAN TERHADAP KORELASI DATA HASIL PENGUKURAN SEISMIK LUBANG BOR PADA LOKASI UNDERGROUND COAL GASIFICATION *MENGGUNAKAN* MULTIVARIATE ANALYSIS

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ABSTRACT

One of the risk potentials that must be alerted for underground coal gasification(UCG) technology is surface subsidence, although such a technology is potential to be developed in Indonesia. Therefore, the characteristics of rock strata above the coal seam needs to be deliberately considered. Downhole seismic data is one of the data that is needed to determine the geotechnical characteristics of the rock layers near the surface. Previously, it is considered that physical, mechanical and dynamic properties of the rocks at same geological formation have equal characteristics although they come from different locations. However, based on correlation test to downhole seismic data using multivariate analysis showed that no significant correlation between the measured data from Macangsakti-1 and Macangsakti-2 with those of Mahayung from different location, although they are in the same geological formation. This fact is shown by the analysis result which shows a significance value of <0.05. Macangsakti-1 and Macangsakti 2, which are located closely, showed a significant value of >0.05. It means that there are no significant data differences between the two locations. It is very likely since there are a lot of factors that affect such conditions, especially the influence of tectonics at each location. In addition, factors of the surface condition such as infiltrations of ground water from the surface towards the unsaturated zone also affect the difference of wave propagation velocity at each location. Thus, it should be noted that the condition of rock layers are site specific to determine the characteristics of the sites it should be measured at the sites and can not be generalized with other locations, although they are in the same geological formation.

Keyword: underground coal gasification, downhole seismic, multivariate analysis

ABSTRAK

Meskipun teknologi gasifikasi batubara bawah tanah atau underground coal gasification (UCG) *sangat berpotensi untuk dikembangkan di Indonesia, namun perlu diwaspadai adanya potensi resiko teknologi ini, salah satunya adalah penurunan permukaan tanah. Oleh karena itu karakteristik lapisan batuan yang berada di atas lapisan batubara perlu diperhatikan secara seksama. Data seismik lubang bor adalah salah satu data yang dibutuhkan untuk mengetahui karakteristik geoteknik perlapisan batuan yang berada di dekat permukaan. Sebelumnya sifat fisik, mekanik dan dinamik batuan pada formasi sama meskipun pada lokasi berbeda dianggap mempunyai karakteristik yang sama. Namun berdasarkan uji korelasi terhadap data seismik lubang bor dengan menggu-nakan analisis multivariat menunjukkan tidak adanya korelasi signifikan antara data hasil pengukuran di lokasi Macangsakti-1 dan Macangsakti-2 dengan lokasi Mahayung yang berada di lokasi yang berbeda, meskipun*

Received : 11 February 2015, first revision : 24 July 2015, second revision : 22 September 2015, accepted : October 2015

formasi geologinnya sama. Kenyataan ini ditunjukkan oleh hasil analisis yang memperlihatkan nilai signifikansi < 0,05 sedangkan antara lokasi Macangsakti-1 dan Macangsakti-2 yang lokasinya berdekatan menunjukkan nilai signifikansi > 0,05. Artinya tidak terdapat perbedaan data yang signifikan antara ke dua lokasi tersebut. Hal ini dimungkinkan karena banyak faktor yang mempengaruhi kondisi tersebut, terutama pengaruh tektonik pada masing-masing lokasi. Selain itu faktor kondisi permukaan, terutama infiltrasi air tanah dari permukaan ke zona tidak jenuh, akan mempengaruhi perbedaan kecepatan rambat gelombang pada masing-masing lokasi. Patut menjadi perhatian bahwa di lokasi tertentu, kondisi perlapisan batuan sangat khas sehingga untuk mengetahui karakteristik suatu lokasi harus dilakukan pengukuran di lokasi tersebut dan tidak bisa disamakan dengan lokasi lain meskipun formasi geologinya sama.

Kata kunci: gasifikasi batubara bawah tanah, seismik lubang bor, analisis multivariat

INTRODUCTION

Based on the calculation of coal resources, Indonesia retains 161 billion tons of coalif such quantities are exploited at current production levels, it will satisfy the need of coal up to 150-200 years. Approximately 120 billion tons of coal can be mined using an open pit method and the rest by underground mining technique (Badan Geologi, 2012). Due to most Indonesian coals are low rank type and available at a depth of more than 150 meters, it is generally not feasible to be mined conventionally by either open or underground minings. underground coal gasification (UCG) technology is one of the technologies that can overcome the problems. It is a process that extracts the coal into gas through two drilled boreholes without excavating the rock. One hole serves as catalyst injection and another as production well. This technology reduces environmental problems, optimizes uneconomical coal utilization and also covers energy deficiency derived from oil and gas. UCG also lowers the capital investment by eliminating the need for specialized coal processing (transporting and stocking) and gasification reactors (Bhutto et al., 2012). The technology has been conducted in several countries but it is stopped due to the petroleum discovery as an easy mined-energy. Since the oil crisis, some countries has begun developing UCG technology and the current commercial project has grown in America, Canada, South Africa, India, Australia, New Zealand and China, which produce electricity and liquid fuels as well as synthetic natural gas. Although the UCG is potential to be developed in Indonesia, but it should be noted regarding the potential risk. One of the risks is the ability of overburden to resist the temperatures and pressures from the process. If there is a leakage, it will cause groundwater pollution due to organic contaminants from the seam produced during UCG process (Torres et al., 2014). The next potential risk is land subsidence. As coal combustion will produce underground cavity that will collapse and danger surface infrastructure.

R & D Center for Mineral and Coal Technology (*tek*MIRA) currently starts conduct initial research by conducting several tests on sub-surface conditions at the site planned for UCG pilot plant in South Sumatera. One of the tests is downhole seismic measurements. Its data will be used to determine geotechnical characteristics of the rock near the surface. In general, the downhole seismic measurement used to determine the propagation speed of compression (P) and shear (S) waves. Velocity data are used to evaluate the seismic response and determines elasticity modulus as well as stratigraphic conditions of a study site. Wave propagation of rock masses provides accurate information about physico-mechanical properties or state of the masses rock. Downhole seismic data were obtained from 5 (five) drilling points, the two of them were from Macang Sakti village, Sangadesa District, Banyuasin Regency, South Sumatera and 3 (three) other data derived from Mahayung location, Tanjung Enim District, Muara Enim, South Sumatera. Though all rocks are in the same formation, their dynamic characteristics are the same for one another. Due to more than one dependent variables, multivariate test is used to evaluate such the data. Early hypothesis states that there is a correlation among dynamic charcterisctics of the rocks at several locations. However such a statement needs to be proved by evaluating the correlation among derived downhole seismic data.

The aim of this study is to compare the petrophysical condition of rock at different locations on the same rock formation (Muaraenim formation) using the downhole seismic data. The reason selecting of this location, the derived data are required for analyzing subsurface conditions, particularly geotechnical aspects that are very important in the development of UCG in South Sumatera.

METHODOLOGY

Downhole Seismic Data

The data were derived from primary and secondary wave propagations in several rock layers that were vertically transmitted from the surface into the downhole. The determined parameter was shear wave velocity (Vs). The maximum shear modulus of soil is function of the shear wave velocity (Ghazi, et al., 2015). Wair et al. (2012), said that the shear wave velocity (Vs) is especially a valuable indicator of the stress-strain behaviour of soil due to its relations to the small-strain shear modulus (Gmax). Downhole seismic measurement was conducted by reading compression and shear wave velocities of the rock layers passed through to the geophone. Shear wave velocity profile was an input for the software used to process the data. The software was Geo-2X that calculate reinforcement and spectrum response vibrations of each rock. The soft rock will cause the biggest vibration reinforcement. As a result, the USG structure needs to reinforced by specific construction. While, the hard rock causes minimum reinforcement vibration. Vertical wave propagation velocity was gradually measured from top to down by setting geophones on each meter of the borehole. The study used three geophonesors known as triaxial geophones which have perpendicular directions. The objective of using this geophone was to ease in determining the S wave arrival time that comes after the P wave. The S was the polarized wave. The characteristics used to determine accurate arrival time of the S wave was by recording the wave sources with different punch direction. By evaluating the phase changes of the arrival wave, it can be determined at the arrival time of S wave after wave of P. From downhole seismic measurements, it will be obtained the profile of shear wave velocity as an input for wave propagation analysis programs from the bedrock to the ground surface. Instrument for recording the waves was PASI 09091129N. While, the used geophones was a triaxial one. Due to differences in depth, there were several techniques for collecting data at each hole.

The shear wave was measured by using a crossbar with dimension of 225 x 22 x 20 cm and horizontally hit. The distance from borehole center to the crossbar was 2 meters and sampling interval for measuring the desired parameters at the drill hole was 1 m for the depth of 0 to 11 m and 2 m for 11 to the measurable limit. The chanels used for recording purpose were 10, 11 and 12. Although it was carried out for the measurement several times, but the desired depth (up to 100 m) can not be reached because of the collapse occurred at the borehole wall. Figure 1 shows the activity of downhole seismic measurements at drilling location.

Figure 1. Downhole seismic measurements in a borehole

Stratigraphy of Research Area

Stratigraphy of the reasearch area included in Muaraenim formation that lies conformably on Air Benakat formation. Muaraenim formation is an upper Miocene – lower Pliocenecoal-bearing formation. Shell (1978) divided the formation based on the available of coal seam into 4 (four) members, namely M1, M2, M3 and M4. Based on the results of shallow drilling, not the entire members could be penetrated by the drill. This formation was deposited as a continuation of regression phase along with member that consists of:

Members M1: The M1 performs recurrence of sandstone, siltstone, claystone and coal. Normally, they show light green and gray-brown in color. Lenticular structure is common within claystone. Coal in M1 at study area was not developed and only found as intercalation with thickness of 0.10 - 0.20 m;

Members M2: The M2 consists of claystone,carbonaceous claystone, siltstone, sandstone and coal. Carbonaceous clay stone performs dark gray, generally massive, partly parallel lamination, and retains plant remain and coal fragments. The M2 usually encloses the coal seam. There is only one coal layer within the M2 with the thickness between 7.20 – 10.00 m unit is usually found as a rock clamp coal;

Members M3: The M3 contains sandstone, siltstone, clay stone and coal. Sandstone is light gray, very fine grained, well sorted, quartz dominant, bad cemented. Siltstone light gray greenish-brown, compact, parallel lamination, traces of plants. Claystone performs as roof and floor of the coal seam. Coal is found in 2 layers with a thickness around 7.00 and 5,00 m;

Members M4: The M4 mainly composed by claystone and sandstone as well as some coal seams.

Muara Enim and Kasai Formation deposited at study area at which Muara Enim formation represented the final stage of tertiary regression. This formation deposited conformably on Air Benakat formation within shallow marine, paludal, delta plains and non-marine environment its thickness of around 500 - 1000 m and consists of sandstone, claystone, siltstone and coal. Sandstones in this formation comprises glauconite and volcanic debris. The formation also contains iron oxides in concretion shapes as well silicified wood. Lignite is the main coal type found in this formation within Muara Enim Formation. The formation occurred at late Miocene - early Pliocene. Kasai Formation was conformably deposited with Muara Enim Formation its thickness between 850 - 1200 m and consists of tuffaceous sandstones andrhyolitic tephra at the bottom. The upper part consists of quartz-rich pumice, sandstone, conglomerate, sandy tuff withpumice-containing rudite lenses and tuff and mostly silicified. Its sediment facies is fluvial and alluvial fan. The quaternary unit is the youngest lithology that is unaffected by Plio-Pleistocene orogenesis. The unit is unconformably deposited on top of older formations that consist of swamp depositin the form of mud, silt and sand, while the alluvium deposit consists of clay, silt, sand, conglomerate fragments from pebbles to boulders, andesitic-basaltic volcanic rock. This rocks unit is Recent.

Multivariate Analysis

MANOVA or multivariate analysis of variance was used for analyzing the data of MS1, MS2 and Mahayung. The fact that there were two dependent parameters and two independent parameters for correlating the data from several locations was the reason to use MANOVA. Ghozali (2013) states that the amount of the dependent variable more than one dependent parameters (metric or interval) and one or more independent parameters (non-metric or nominal) should use multivariate analysis. MANOVA models compares the n mean vector as Xij = μ+ τi + eij, j = 1, 2, 3,…,ni and I = 1, 2, 3, …n. Observation vector can be written as:

xij	=	$\bar{x}$	+	xi - x	+	xij - xi
obser-vation		Mean of total samplem)		Estimated treatmentti)		Residue eij

The tested nullhypothesis can be formulated as H0: τ1 = τ2 = τ3 = … = τg = 0. Comparing the mean vector in Manova analysis can use formulation as shown in Table 1.

Tabel 1. MANOVA formulation for comparing mean vector

Variation	Matrix of Number of Squares and Multiplication Cross	Degree of Freedom
Treatment	$B = \sum_{i=1}^{g} n_i(x_i - x)(x_i - x)'$	g-1
Residue (Error)	$W = \sum_{i=1}^{g}\sum_{j=1}^{n_i}(x_{ij} - \bar{x})(x_{ij} - \bar{x})'$	$\sum_{i=1}^{g} n_i - g$
Total (Corrected Mean)	$B + W = \sum_{i=1}^{g}\sum_{j=1}^{n_i}(x_{ij} - \bar{x})(x_{ij} - \bar{x})'$	$\sum_{i=1}^{g} n_i - 1$

Furthermore, the value of B and WΛ* coefficient using formula $\lambda=|W|/|B+W|$. The null hypothesis H0 : $\tau 1 = \tau 2 = \tau 3 = \ldots = \tau g = 0$ was rejected if λ too small. The λ coefficient called Wilks lambda. Accurate λ distribution for H0 testing is shown in Table 2 (Patel and Bhavsar, 2013). This multivariate calculation uses IBM SPSS Statistics 20.

Recording). The signals reachs the geophones to be recorded and then used to determine the arrival time of the shear wave. Result of compression wave test is shown in Figure 5. The interval wave velocity between successive depths can be calculated based on the interval travel path and measured interval travel times. A summary of downhole test results is illustrated in Figure 6.

Tabel 2. Calculation process for λ value

Number of Variables	Number of Group	Sampling Distribution	F
p = 1	g $\geq$2	$\left(\frac{\sum n_i - g}{g-1}\right)\left(\frac{1-\lambda}{\lambda}\right)$	Fg-1, ∑ni-g
p = 2	g $\geq$2	$\left(\frac{\sum n_i - g - 1}{g-1}\right)\left(\frac{1-\sqrt{\lambda}}{\sqrt{\lambda}}\right)$	F2(g-1), 2($\sum n_i$-g-1)
p $\geq$1	g = 2	$\left(\frac{\sum n_i - p - 1}{p}\right)\left(\frac{1-\lambda}{\lambda}\right)$	Fp, $\sum n_i$-p-1
p $\geq$1	g = 3	$\left(\frac{\sum n_i - p - 1}{p}\right)\left(\frac{1-\sqrt{\lambda}}{\sqrt{\lambda}}\right)$	F2p, 2($\sum n_i$-p-2)

RESULTS AND DISCUSSION

Lithology and Measurement results of Downhole Seismic

There were 6 (six) drilling points in the village Macang Sakti, Sangadesa District, Musi Banyuasin Regency in 2014 by tekMIRA, namely UCG-1, UCG-1A, UCG-1B (Area I), UCG-2, UCG- 2A, and UCG-2C (Area II). Due to limited timefor conducting downhole seismic measurement, the measurement was only conducted of 5 drilling points, namely UCG-1, UCG-1B, UCG-2, UCG-2A, and UCG-2C while the data from Mahayung Block, Tanjung Enim District, Muara Enim Regency were obtained from three (3) drilling points, ie UCG-1TA, UCG-2TA and UCG-3TA (Area III) results conducted in 2013. Figures 2 and 3 represent the lythologic condition of study areas at the depth of 35 m while Table 3 and 4 show the speed of P and S propagation waves.

To generate compression wave or P waves, the hammer was hit to the horrizontally resting cross bar (Figure 4). The generate wave will be perpendicular to the direction of wave propagation to be recorded by seismic recorder (PASI Seismic Recording).

Interpretation of the analysis results
Several steps were conducted to interprete the measurement results. Those were:

a. Testing Homogeneity of Variance
   Testing homogeneity of variance refers to Levene analysis as shown in Table 5.

   Levene tests (Table 5) shows that wave propagation velocity (m/s) of F= 0.164, its significance is 0.849 while for depth (m) of F = 0,00; its significance is 1. If the significance is determined for 0.05 or the reliance is 95%, either m/s or m has a homogen variance. It means that the MANOVA test can be continued.

b. Testing Homogeneity ofvariance/covariance matrices
   The MANOVA requires that variance/covariance matrices of the dependent variable should be equal. It needs testing homogeneity of variance/covariance matrices as seen in Table 6. If the value of Box's M value is significant, then the null hypothesis statement that

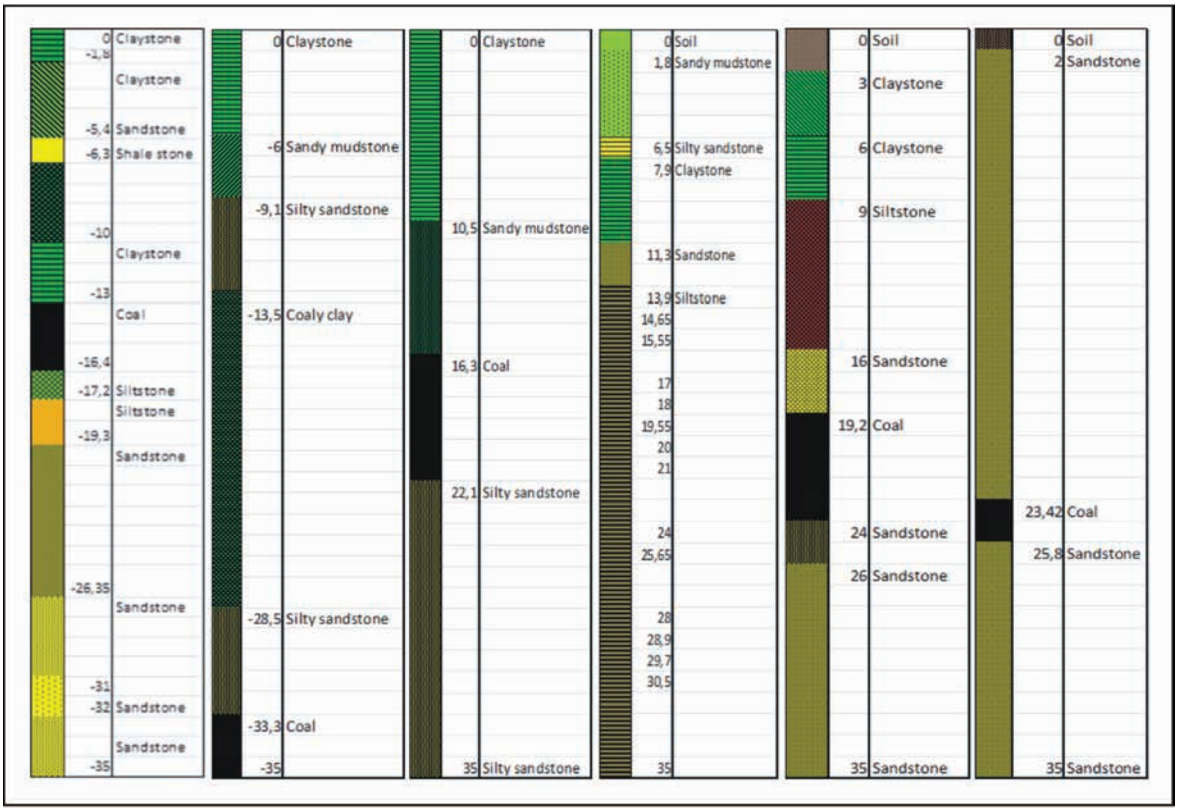

Figure 2. Lithologic of Macang Sakti location for 35 m depth

Table 3. Result of downhole seismic measurement of 1 to 35 m depth at Macang Sakti location

Depth (m)	UCG-1 (m/s)		UCG-1B (m/s)		UCG-2 (m/s)		UCG-2A (m/s)		UCG-2C (m/s)	
	P-Wave	S-Wave	P-Wave	S-Wave	P-Wave	S-Wave	P-Wave	S-Wave	P-Wave	S-Wave
1	301,7	155	370,4	200	377	217	363	205	370	225
3	512,9	263	546,6	295	449	252	416	193	454	238
5	481,7	247	622,9	337	730	406	549	278	449	410
7	374,6	192	970,3	524	784	558	542	272	525	788
9	1569,3	805	542,4	293	1030	656	888	291	956	850
11	1450,9	744	958,7	518	1010	851	1013	429	998	893
13	1627,9	835	928,5	502	1285	954	1091	677	1071	958
15	1529,7	784	1606,2	868	1152	925	1104	690	1084	1020
17	1546,6	793	1623,9	878	1096	891	1111	758	1154	1085
19	1557,4	799	1635,2	884	1636	1090	1350	838	1231	1155
21	1564,5	802	1642,8	888	1464	1309	1356	935	1316	1160
23	1569,5	805	1648,0	891	1468	1315	1463	1091	1320	1164
25	1573,1	807	1651,8	893	1325	1319	1587	1229	1796	1238
27	1575,7	808	2469,5	1335	1803	1240	1732	1233	1978	1168
29	1577,7	809	2475,0	1299	1985	1323	1592	1410	1804	1242
31	2346,7	1024	2479,3	1322	2206	1419	1472	1320	2203	1106
33	2207,5	1020	2482,6	1242	2482	1473	1912	1322	2479	1244
35	2483,7	1032	2485,2	1419	2485	1373	1913	1418	2834	1328

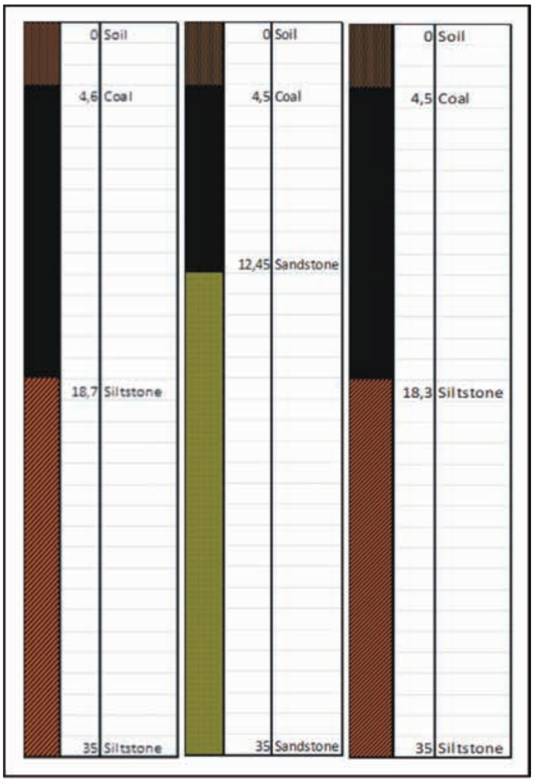

Figure 3. Lithologic condition of Mahayung location for 35 m depth

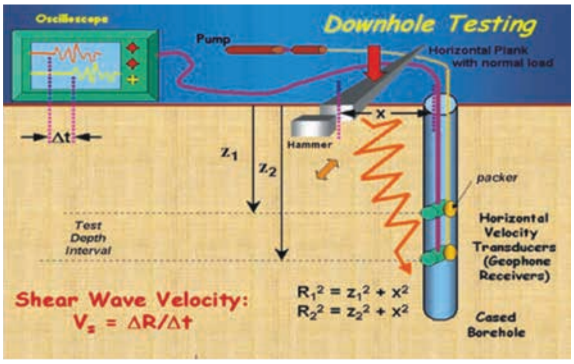

Figure 4. Setup and data reduction procedures for conducting a downhole seismic survey (Mayne, et.al., 2001)

suggests the variance/covariance matrices of the equal dependent variabelsare rejected. In this condition, MANOVA analysis cannot be continued.

Calculation of IBM SPSS Statistics Version 20 shows that the value of Box's M = 6.166 with significance of 0.419. If the significance level for research was set 0.05, then the value of Box's M was insignificant because the ob-

Table 4. Result of downhole seismic measurement of 1 to 35 m depth at Mahayung location

Depth (m)	UCG-1TA (m/s)		UCG-2TA (m/s)		UCG-3TA (m/s)	
	P-Wave	S-Wave	P-Wave	S-Wave	P-Wave	S-Wave
1	392	166,9	417	190,5	400	177,8
3	505	214,9	583	239,0	515	229,1
5	1364	580,5	1350	381,0	1392	618,7
7	1502	639,0	1649	698,7	1532	681,0
9	1528	650,0	1541	713,4	1559	692,8
11	1585	674,3	1728	743,8	1617	718,7
13	1614	686,8	1928	795,6	1647	732,0
15	1631	693,8	1779	805,4	1664	739,5
17	1641	698,1	1644	899,1	1674	744,0
19	2093	890,5	1649	857,4	2135	949,1
21	2017	858,1	2103	907,3	2058	914,6
23	2248	956,7	2023	935,3	2294	1019,6
25	2476	1053,4	2254	993,3	2526	1122,7
27	2480	1055,4	2481	1025,6	2531	1124,8
29	2484	1056,9	2484	1094,8	2534	1126,3
31	2486	1058,0	2487	1095,9	2537	1127,6
33	2488	1058,9	2489	1096,8	2539	1128,5
35	2490	1059,6	2491	1097,6	2541	1129,3

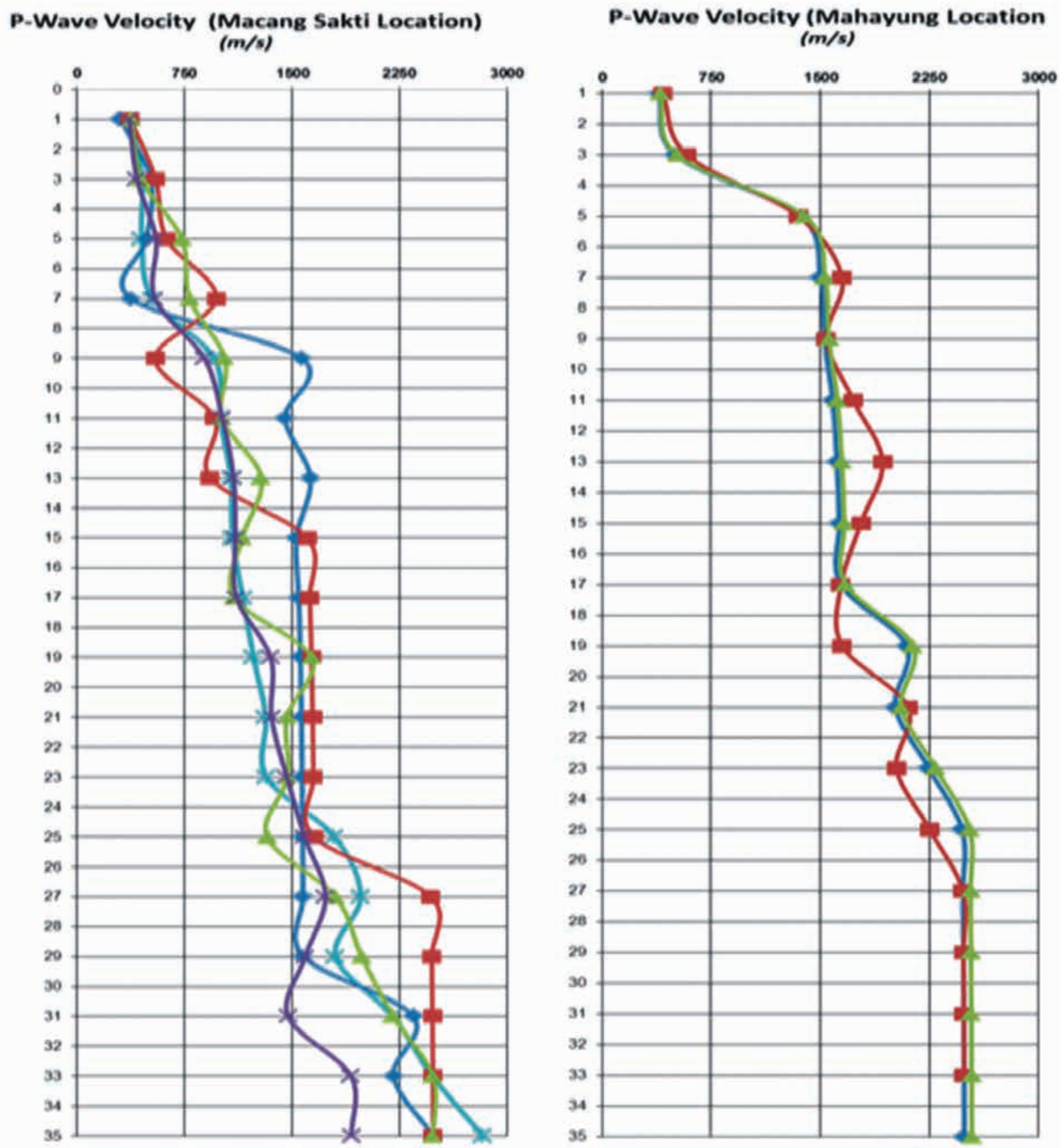

Figure 5. Curves of compression wave velocity

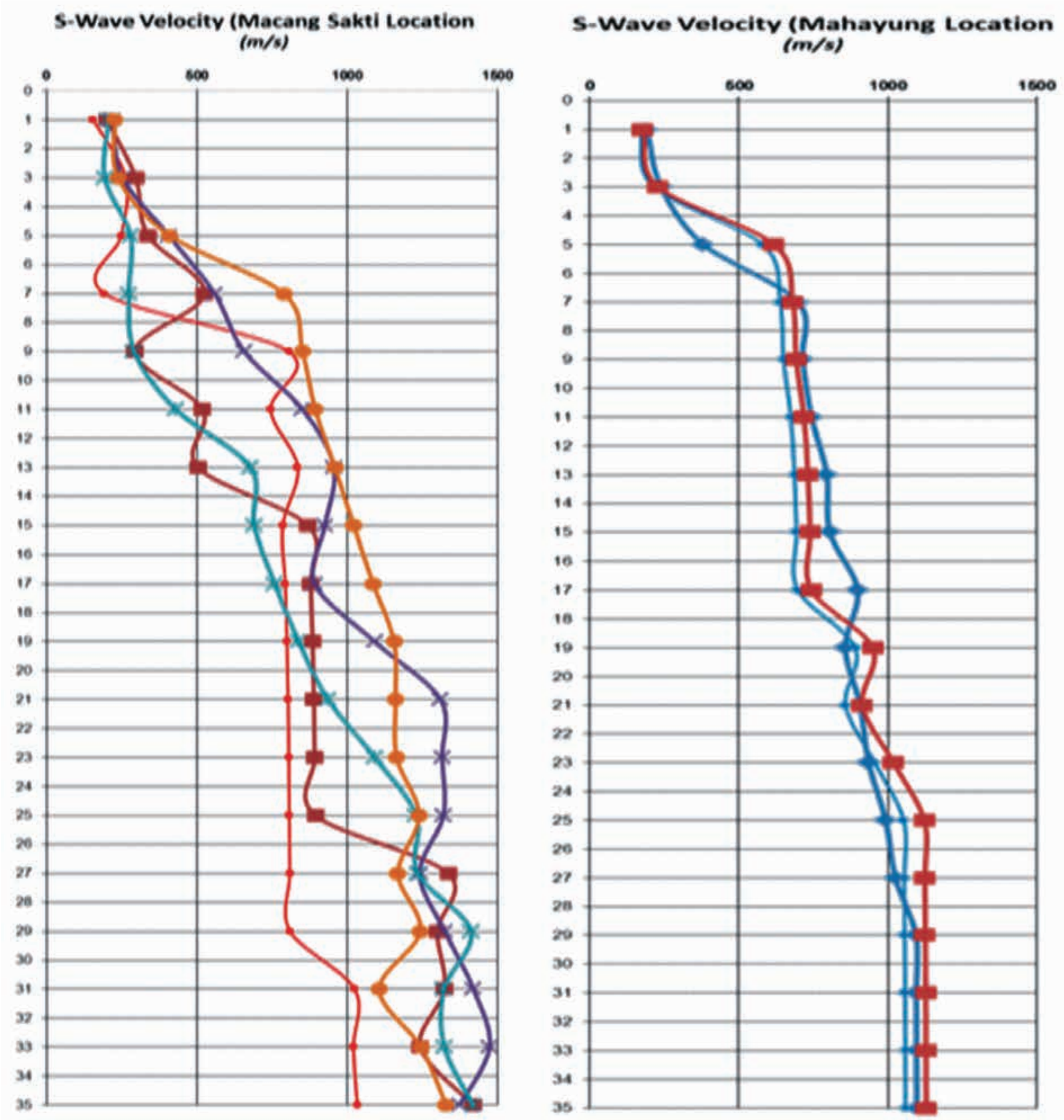

Figure 6. Curves of shear wave velocity

Table 5. Levene's test for equality of error variances

	F	df1	df2	Sig.
m/s	0.164	2	141	0.849
m	0	2	141	

Tabel 6. Box's test for equality of covariance matrices

Parameters	Value
Box's M	6.166
F	1.006
df1	6
df2	225780.936

tained value (0.419) more than 0.05. Thus. the null hypothesis is acceptable that means variance / covariance matrices of dependent variable is equal. The MANOVA analysis can be continued.

c. MANOVA test
MANOVA test was used to analyze whether differences in some bound variabels between several different groups or not. In this case, it was distinguished the data from measurement of P and S wave velocities measurement depth and measurement location. Table 7 shows the results of multivariate tests using several calculation namely Pillai's Trace. Wilks' Lambda. Hotelling's Trace and Roy's Largest Rootmethods.

no significant differences in the data between both locations. It can be concluded that although they are in same formation, the measurement results of P and S propagation wave using downhole seismic weren ot equal for Mahayung, Macangsakti-1 and Macangsakti-2. No significant differences for measurement data for Macangsakti-1 and Macangsakti-2.

CONCLUSION

The measured data showed insignificant value to one another although their measurements were carried out within same geological formations and rock bedding conditions. The multivariate test results of multiple testing methods showed

Table 7. Multivariate tests

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	
Intercept	Pillai's Trace	0.884	532.467b	2.000	140.000	0	0.884
	Wilks' Lambda	0.116	532.467b	2.000	140.000	0	0.884
	Hotelling's Trace	7.607	532.467b	2.000	140.000	0	0.884
	Roy's Largest Root	7.607	532.467b	2.000	140.000	0	0.884
Location	Pillai's Trace	0.513	24.326	4.000	282.000	0	0.257
	Wilks' Lambda	0.487	30.315b	4.000	280.000	0	0.302
	Hotelling's Trace	1.054	36.615	4.000	278.000	0	0.345
	Roy's Largest Root	1.054	74.285c	2.000	141.000	0	0.513

Pillae Trace, Wilk Lambda, Hotelling's Trace, and Roy's Largest Root tests (Table 7) indicate that the significant of F was< 0.05. It means that the F for Pillae Trace, Wilk Lambda, Hotelling's Trace. Roy's Largest Root were significant. Thus there was significant differences of the measurement results for each measurement location.

d. Post Hoc Test
Using the Post Hoc test for correlating all velocity data of P and S waves from 3 locations (Table 8), there was significant diffrences of data from Macang Sakti 1, Macang Sakti 2 and Mahayung as shown by significance value of <0.05.

Locations of Macangsakti-1 and Macangsakti-2 show significance value of > 0.05. It means that

the lowest significance. Multiple comparisons and post hoc tests showed that significant correlation between the measured data of Macangsakti-1 and Macangsakti-2, but no significant correlation of Mahayung. A lot of factors especially the tectonics influence in each location that affected these conditions. In addition, the surface condition factor, especially ground water infiltration from the surface to the unsaturated zone also affected these conditions caused the difference of wave propagation velocity at each location. Referring to this condition, it should be noted that the condition of rock layer is a very specific site.Thus, it should be a concern that the condition of rock layering is avery specific site. Therefore, to identify the characteristics of a site, it should be measured at the site and cannot be equated with other locations, although in the same formation.

Table 8. Multiple comparisons of Mahayung, MacangSakti1 and MacangSakti2 Locations

Dependentt Variable		(I) Site of Hole	(J) Site of Hole	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
m/s	Tukey HSD	Macang Sakti1	Macang-Sakti2	171.16	137.845	0.431	-155.36	497.68
			Mahayung	-376.17*	137.845	0.019	-702.69	-49.66
		Macang-Sakti2	Macang Sakti1	-171.16	137.845	0.431	-497.68	155.36
			Mahayung	-547.33*	123.292	0	-839.38	-255.29
		Mahayung	Macang Sakti1	376.17*	137.845	0.019	49.66	702.69
			Macang-Sakti2	547.33*	123.292	0.000	255.29	839.38
	Bonferroni	Macang Sakti1	Macang-Sakti2	171.16	137.845	0.649	-162.82	505.14
			Mahayung	-376.17*	137.845	0.021	-710.16	-42.19
		Macang-Sakti2	Macang Sakti1	-171.16	137.845	0.649	-505.14	162.82
			Mahayung	-547.33*	123.292	0	-846.06	-248.61
		Mahayung	Macang Sakti1	376.17*	137.845	0.021	42.19	710.16
			Macang-Sakti2	547.33*	123.292	0	248.61	846.06
m	Tukey HSD	Macang Sakti1	Macang-Sakti2	0	2.256	1.000	-5.34	5.34
			Mahayung	0	2.256	1.000	-5.34	5.34
		Macang-Sakti2	Macang Sakti1	0	2.256	1.000	-5.34	5.34
			Mahayung	0	2.018	1.000	-4.78	4.78
		Mahayung	Macang Sakti1	0	2.256	1.000	-5.34	5.34
			Macang-Sakti2	0	2.018	1.000	-4.78	4.78
	Bonferroni	Macang Sakti1	Macang-Sakti2	0	2.256	1.000	-5.47	5.47
			Mahayung	0	2.256	1.000	-5.47	5.47
		Macang-Sakti2	Macang Sakti1	0	2.256	1.000	-5.47	5.47
			Mahayung	0	2.018	1.000	-4.89	4.89
		Mahayung	Macang Sakti1	0	2.256	1.000	-5.47	5.47
			Macang-Sakti2	0	2.018	1.000	-4.89	4.89

Based on observed means.

ACKNOWLEDGEMENT

The authors would like to thank Ir. Eko Pujianto. ME for conducting geophysical measurements downhole seismic project at Mahayung locationas well as guiding the new members of UCG team for collecting data at location Macangsakti-1 and Macangsakti-2. Thanks also go to R & D Center for Mineral and Coal Technology which have facilitated this research.

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