APPLICATION OF GEOPHYSIC METHODS FOR VOLUME ASSESSMENT AND SEDIMENT MATERIALS CHARACTERIZATION FROM THE 2014 KELUD VOLCANO ERUPTION AT THE UPSTREAM OF BLADAK RIVER

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The eruption of Kelud volcano on February, 13th 2014 has produced a huge amount of material at the upstream of Bladak River. The materials are potentially becoming the flood material in downstream area. The mitigation efforts to minimize flood hazard require information of volume of the materials upstream. Moreover, information of physical characteristics of the materials are valuable for the community in the surrounding areas.

Volume assessment and materials characterization were carried out through field measurements. The material volume assessment was done by using geophysical methods to estimate sediment thickness. The types of geophysical methods applied were microseismic method and seismic refraction. The results obtained from microseismic data processing was the value of natural frequency (f_0) at each microseismic measurement point. The results obtained from seismic refraction data processing was the P wave velocity of sediment material, in which the derivative of P wave velocity will be calculated to obtain the S wave velocity. The S wave velocity is used to calculate the thickness of sediment combined with the value of natural frequency through the formula of $h = Vs/4f_0$. The isopach line was produced through interpolation of sediment thickness measurement points. Later, the isopach lines were applied for volume assessment. Characterization of sediment material was done by calculating the percentage of pumice and non-pumice. The sediment material characterization data was processed manually by analyzing through field pictures. The data processing result were then analyzed descriptively. Materials thickness of pumice in land surface was analyzed according to slope classes.

The result of volume assessment of the sediment materials at the upper stream of Bladak River was 27.6 million m^3. The sediment at the upper stream of Bladak River consisted of 91.8% of pumice material. The pumice materials might be valuable for local economic generator as those

materials have several uses, but should be investigated thoroughly through research. The community in the area surrounding Bladak River may exploit the materials for building materials or lightweight concrete materials, abrasive cloth jean or denim, etc. There were no significant correlation between land surface slope with the thickness of materials in the upper catchment of Bladak river.

Keywords: geophysics, sediment materials, Kelud Volcano, Bladak, pumice

INTRODUCTION

Kelud volcano last eruption occured on February 13, 2014. The erupted material was buried in the upstream Bladak river, being a potential source of flood material. The erupted material is unconsolidated so it is easy to collapse when exposed to relatively high intensity and long duration of rainfall. Therefore, the thickness and volume of material deposition is important information for disaster mitigation towards lahar flood in the downstream of the river.

The materials of volcanic eruptions can be major natural resources for economic growth. Utilization of material depends on the characteristics of the sediment material. Therefore, the characteristics of sediment material is important information for their use to people's lives.

Calculation of the volume of sediment is usually done through direct measurements in the field. Calculation of the volume of sediment that has also been used is by doing mapping approach through image interpretation and maps. Calculation based on the volume of sediment with a geophysical survey has not been done due to general high-temperature deposition. The thickness of sediment material from the eruption of volcanoes can be determined by geophysical measurement method, that is seismic refraction (Darmawan et al., 2013). Another study is conducted by Karstens et al. (2013) which measured the thickness of the sediment material volcano using 3D seismic data. The application of geophysical approach for the measurement of the volume of material deposition is possible to do.

Purposes of the study achieved through the stages of research objectives are as follows: (1) to calculate the depth and volume of sediment material Kelud Volcano eruption in 2014 in the upstream of Bladak river using geophysical surveys (2) to identify the characteristics of the sediment material of Kelud Volcano eruption in 2014 in the upstream of Bladak river by percentage of non-pumice and pumice (3) to establish recommendations to the community ~~of~~ regarding sediment material utilization in the upstream Bladak catchment.

Methods

The method applied in this research are field survey methods. Field surveys conducted by using transect/observation track. Field measurement points of microseismic method are shown as green points in Figure 2.1. The total amount off Microseismic measurement points amounts to a total of 19 points. The distance between points is approximately 500 meters adjusted to the field conditions. Refraction seismic measurements are shown as dark red lines. The number of seismic refraction lines is two and the length of each line is 48 meters. The measurements being performed twice at each line are forward measurement and reverse measurement.

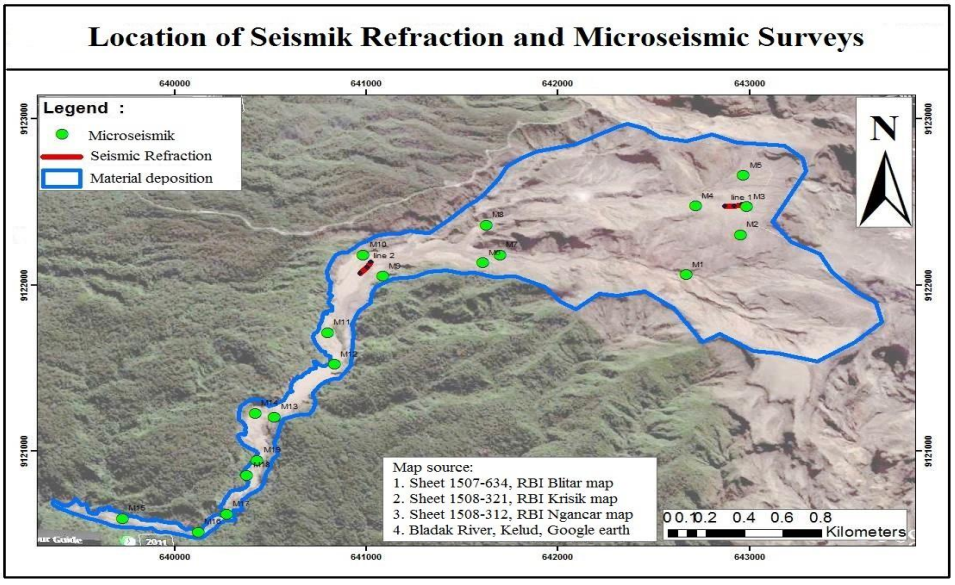

Figure 2.2 Location of Seismic Refraction and Microseismic Surveys

The processing of microseismic data is done by using Geopsy software and Microsoft Excel, and the processing of seismic refraction data is done by using Geosam viewer software and Microsoft Excel. Calculation of the volume of material deposition is done by using Petrel 9.1 software. The 2D display of distribution of material deposition is done by using Petrel 9.1 software and Acrgis 10.1 software.

Identifying the characteristics of the deposited material is done directly in the field. Sampling or measurement in the field is done by making a grid of 1 metre x 1 metre in every measurement point then to be photographed using a camera. Calculation of

percentage of pumice and nonpumice is done by creating a grid on each photograph.

In-depth interviews were conducted to several key persons/respondents around the upstream of Bladak catchment. Respondents are people who often have activities in the upstream of Bladak catchment. Respondents were chosen among other plantation farmers, sand miners, etc.

Measurement of morphological characteristics of the territory is done through the interpretation of RBI map to obtain slope information.

RESULTS AND DISCUSSION

The field data of microseismic measurement results is processed using Geopsy software to get the value of f_0. Seismic refraction data has processed and resulted in a value of 95 m/s of S-wave velocity. The thickness of sediment materials was calculated by using formula $h = Vs/4f_0$. The values of f_0 and material thickness are shown in Table 3.1.

Table 3.1 Material thickness and f_0 value for each mikroseismic point

Point	Coordinate (UTM)		Elevation (m)	f_0 (Hz)	Thickness (m)
	x	y			
M1	642669	9122061	1108	12,2	1,95
M2	642952	9122302	1229	1,34	17,72
M3	642985	9122470	1255	1,3	18,27
M4	642717	9122475	1188	1,8	13,19
M5	642967	9122659	1228	1,35	17,59
M6	641605	9122133	1005	6,49	3,66
M7	641696	9122181	1017	4,44	5,35
M8	641623	9122360	1039	4,78	4,97
M9	641085	9122053	972	1,28	18,55
M10	640983	9122181	951	1,5	15,83
M11	640795	9121712	918	1,33	17,86
M12	640833	9121521	903	3,14	7,56
M13	640520	9121204	863	3,78	6,28
M14	640418	9121226	862	2,9	8,19
M15	639724	9120593	744	3,78	6,28
M16	640121	9120510	779	4,88	4,87
M17	640270	9120618	784	6,12	3,88
M18	640376	9120852	829	3,1	7,66
M19	640429	9120944	820	4,5	5,28

Based on the calculation of field data, the volume of sediment material in the upstream Bladak river is 27,6 million m^3. Distribution of material thickness is shown in Figure 3.1.

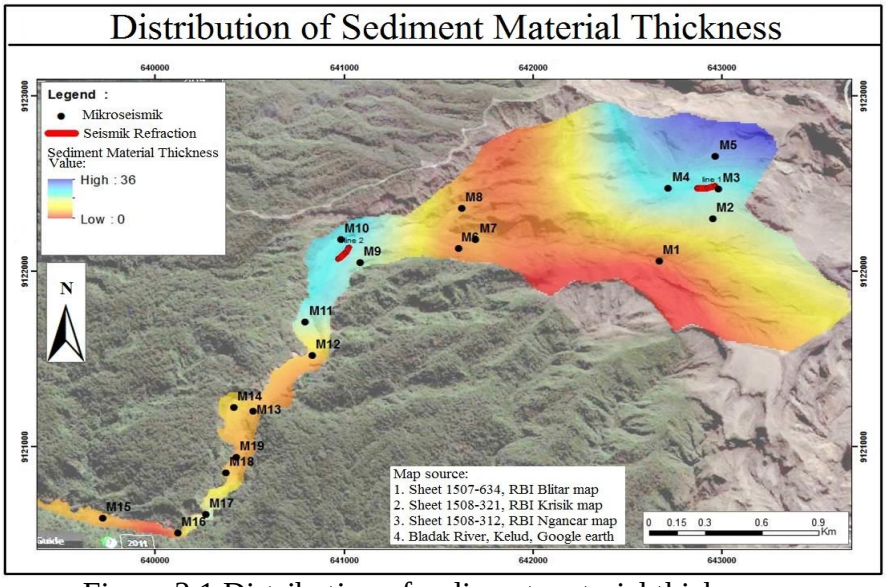

Figure 3.1 Distribution of sediment material thickness

Slope classes and topography according to USLE are shown in Table 3.2. Sediment material thickness classes are shown in Table 3.3. Sediment material thickness classes are made based on the thickness of the sediment material from geophysical measurement results which are plotted on 19 microseismic points. Slope and thickness classes are arranged in a crosstab to see the relationship between the slope and thickness classes.

Table 3.2 Slope classes and topography

Slope classes (degrees)	Topography
<1	Flat
1-3	Wavy
3-6	Corrugated
6-9	Hilly
9-25	Mountainous
25-65	Steep mountainous
>65	Very steep mountainous

Source: USLE (Universal Soil Loss Equation)(Muta'ali, 2012)

Table 3.3 Sediment material thickness classes

Sediment material thickness classes (meter)	Thickness
1-6	Thin
6,01-12	Moderate
≥ 12,01	Thick

Every microseismic point measurements has a value of slope class. The value of slope value and sediment material thickness can be seen in Table 3.4. The distance of each point on the crater of Kelud is shown in Table 3.4 as well. The farthest point from the crater of Kelud is the point M15.

Table 3.4 Thickness value and Slope

Point	Thickness (meter)	Slope (degrees)	The distance of each point to the crater of Kelud (meter)
M1	1,95	9 - 25	716
M2	17,72	9 - 25	433
M3	18,27	9 - 25	434
M4	13,19	9 - 25	725
M5	17,59	9 - 25	555
M6	3,66	25 - 65	1812
M7	5,35	25 - 65	1696
M8	4,97	25 - 25	1777
M9	18,55	6 - 9	2334
M10	15,83	> 65	2478
M11	17,86	< 1	2663
M12	7,56	< 1	2714
M13	6,28	> 65	3184
M14	8,19	> 65	3265
M15	6,28	< 1	4163
M16	4,87	25 - 65	3833
M17	3,88	< 1	3640
M18	7,66	< 1	3496
M19	5,28	< 1	3447

Table 3.4 proves that there is always an area that has a gentle slope being deposited by thick material. It is also influenced by the type and size of the material contained in Bladak River. Thick sediment material is more widely available in areas that have gentle slope, thus requiring a large flow of

water and heavy to be transported, compared to the areas with steep slope.

The greater the degree of slope, the greater the potential of material transported. Rated slope should be linked to the sediment material thickness in the upstream of Bladak river. Classes of slope are then arranged in crosstab with classes of material sediment thickness as shown in Table 3.5.

Table 3.5 Crosstab correlation between sediment material thickness classes and slope classes

Thickness (meter)	Slope (degrees)						
	<1	1-3	3-6	6-9	9-25	25-65	>65
1-6	1	1	1	1	2	3	3
6,01-12	1	1	2	2	3	3	3
≥ 12,01	2	2	2	3	3	3	3

The value of the level of vulnerability to landslides (transported sediment material):

1 = Low
2 = moderate
3 = high

Transported sediment material is related to the physical environmental conditions of upstream of Bladak river. In a rain event that has great intensity and long duration, the precipitated material contained in the upstream of Bladak river can be transported and carried into the middle part of Bladak river. However if the rain only has small intensity and short duration, possibility of sediment transporting will only occur in a small stream of water. It will only erode the deposited material and transport them smoothly to the edge of the river. Seeing the fact that until now the material contained in the upstream of Bladak river has not been transported to the downstream, it shows that the rain water infiltrates directly into the ground. The thickness of the material is not affected either by the slope surface.

Looking from the upstream of Bladak catchment, it is not possible to take out the sediment material at the site of the sampling points. The material can be used by local community of Bladak river only when it is already at the center of the river. Calculation result of percentage of pumice and nonpumice is shown in Table 3.6.

Table 3.6 Percentage of *pumice* dan *non-pumice*

Point Name	***pumice (%)***	***non-pumice (%)***
M1	91	9
M2	96	4
M3	88	12
M4	73	27
M5	94	6
M6	96	4
M7	92	8
M8	99	1
M9	89	11
M10	86	14
M11	89	11
M12	100	0
M13	91	9
M14	97	3
M15	81	9
M16	83	17
M17	95	5
M18	99	1
M19	98	2
Total (%)	**91**	**9**

The results of interviews to some of the residents in the Bladak catchment informed that the utilized sediment materials are only sand and rocks, while pumice has not been used though based on the research note, pumice that covers Bladak river upstream is approximately 90% of total sediment material. Therefore, the existing sediment material in the upstream of Bladak river would be a natural resource that can be economically utilized by people in the neighborhood around Bladak river.

This research is useful for recommendation to the local community and stake holder residing in the upstream of Bladak watershed. In addition to the recommendation, innovation is also discovered from this study, that is the benefit of this research in the field of education, especially in the field of geophysics. This study proved that the methods of seismic refraction and microseismic are less suitable to be used for sediment material that is mostly consists of pumice. This is evidenced by the data obtained in the field research.

CONCLUSION

The measurement of the volume of sediment material was conducted using geophysical methods, specifically seismic refraction and microseismic method. The volume of sediment material obtained is 27.6 million m^3. In regard to the physical condition of the environment in the upstream of Bladak river, the material thickness in the upstream of Bladak river is not affected by the slope surface.

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