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"1000 YEARS MERAPI PAROXYSMAL ERUPTION"

Theme:

Volcano: life, prosperity, and harmony

UPN "Veteran" Yogyakarta | Indonesian Association of Geologists | International Union of Geological Sciences | Government of Yogyakarta Special Province | Government of Central Java | Volcanology & Geologic Hazard Mitigation

TOPIC : GROUNDWATER

TOPIC : MAGMATISM AND REGIONAL TECTONIC

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Abstract

Merapi represent a nature glamor amazing, with the trapeze top opening up at west. This volcano oftentimes vomit the heat material, such as dusty rain and hot sand, blast of pyroclastic flows and rock fall of lava. The eruption cycle is short enough, that is about 2 - 7 year. Merapi needs special attention, because in every happened by the eruption will menace human being at least 40.000 people.

Pyroclastic flows often generate disaster. Apart of this gliding sediment can reach the radius more than 10 km with the temperature more than 600 °C and have speed about 300 km /hour. This hot material in the form of dust and sand, the grain size is about 4 - 0.5 mm. Grain size analysis of pyroclastic flows which is taken away from area is near by eruption center till to the slope, showing pattern bimodal, the grain size is 4 mm and 0.250 mm, its mean is the grain size is unsorted. This sediment is effect of process the precipitation by turbulence.

1. Introduction

Gunung Merapi represent the active volcano, owning crater has diameter of 400 m^2. This crater is filled by dome of lava and pyroclastic . This volcano is located in the middle of very populous area, so that if the eruption happens will menace the soul of human being living around its.

The eruption threat the region around Merapi activity which often happens is pyroclastic flows. This pyroclactic is hot material contain block and ash deposite. Blast of pyroclastic flows look like the mushroom or cloud rolling in high-speedly, so that local people at Merapi mention it as "*wedus gembel*".

At this writing accurate piroclastic flows samplas are taken residing at K. Apu, K. Senowo, K. Lamat, K. Putih, K. Batang, K. Bebeng, Boyong, K. Kuning and K. Woro. This Sediment is done by analysis granulometry which aim to know the characteristic distribution grain size of pyroclastic flows of Merapi, so that variation of grain size, like distribution and relation of grain size, and what will be that characteristic. Method used to finish the problems is by using statistical analysis method. Samples pyroclastic flows taken by coarse faction with the grain size which get away the mesh have diameter opening less than 4 mm.

2. Geologic setting

By regional is this Merapi lays in the intersection of two faults, that is direction north - south and northwest - southeast. In the part of summit, this faults expand, so to form the pattern almost look like bow in two place, each started from Gunung of Turgo-slope of east of Gunung Uto with direction northeast-southwest and the west slope of Gunung Ijo-Pusunglondon having direction north-south. The recent product of Merapi often called Gunung Anyar. This gunung represent the most young Merapi and all the activity centrally here. Depression in the summit represent the crater that opening up at southwest. That form affected by eruption 1961.

Gunung Bibi is lapped over by Pre Merapi and this sediment is the oldest rocks, that is old age 400.000 year ago. On the top precipitated of scoria and lava are representing Ancient Merapi (40.000-6700 year ago) and this rock is laid bare in Turgo hill and Plawangan. This Rock is assum as from parasitic eruption. Over lay that sediment is precipitated Middle Merapi (6700-2200 year ago) and Recent Merapi (2200-600 year ago). The Middle Merapi is compiled by Batulawang (older) consisted of the lava and Gajahmungkur (more young) that have association with the sediment pyroclastic. While at Recent Merapi yield the product in the form of lava and piroclastic sediment.

3. Characteristic of Merapi eruption

Merapi activity has taken place since 3400 BP (Newhall, et all, 2000) and at least as much 80 times Merapi erupt in range of year 1548-2001. Repose period of eruption vary between 2-7 year and long repose period is 13 year. The happened at period of eruption 1548-1587 reaching 71 year. The Recent Merapi activity show the short repose period, that is among 1-4 year.

Center and direction of the Merapi eruption make a movement the direction from time to time. According to Yudiantoro, et all (2003) doing to reconstruct to change center the eruption during period eruption from 1786 - 2001, mentioning that movement of center the eruption can be grouped in three period, that is period 1786-1823, period 1832-1872 and period 1883-2001. Eruption period 1786-1823, movement center the eruption is northwest-southeast and only take possession of the middle from top. At eruption period 1832-1872, eruption pattern predominated by pattern of east-west and movement of center eruption early from middle to move west and east. Eruption period 1883-2001, direction of this period center become to vary and very complex, because going about. Characteristic of this eruption center differ from the friction pattern from previous eruption period. As specially to north - south pattern and northeast - southwest representing new pattern and this pattern start to expand at mid from period 1883-2001. The later time periods of eruption is eastward (center the eruption 1786) going to part of west, and then southwards later then.

4. Pyroclastic flows

4.1. Characteristic of pyroclastic flows

Pursuant to genesis, there are two types pyroclastic flows of Merapi, that are pyroclastic avalance and piroclastic eruption. By difine that pyroclastic flows is hot gas and material (300 - 750 °C) what mixed with the fairish material volcanic of block until ash. This hot material effected by slide the lava dome or collapse of column eruption rolling in. The speed of the movement to glide this pyroclastic flows is very high that is range from 100 - 300 km/hour.

The deposites of pyroclastic flows consist of " block and ash" material, generally is unsorted ($6\Phi \geq 2.0$), sometime have good gradation and poorly sorted resulted from by turbulence. Sometime also found fossil of pipe of fumarola or pipe of segregation gas. Found also charge coal, rock of chromatic of orange effect of process the oxidation and accumulation microlite magnetite, iron and or mineral of oxide manganese which that is black color. When hematite oxidized will show the color pink.

Coarse pyroclastic flows often precipitated at river basin, while dusty fairish (ash) disseminate by lateral close over the hill by following wind. Sediment structure is massif, laminated and lamination. Lapilli till ash can be formed a structure " base surge" and because sediment precipitation in a state of very hot and also take place quickly, so that it will form the welded tuff and or ignimbrit.

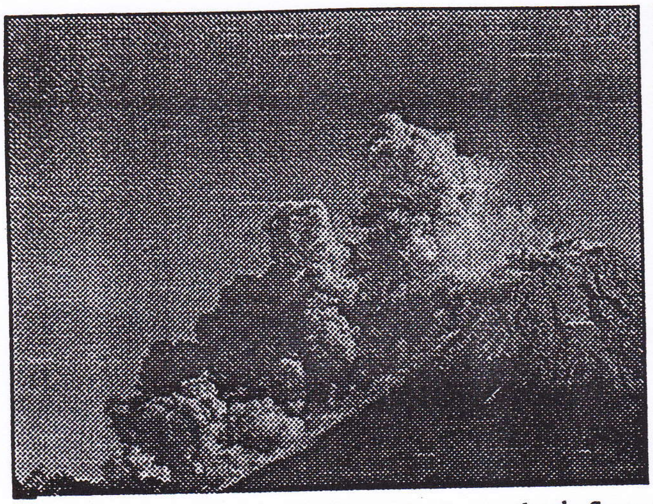
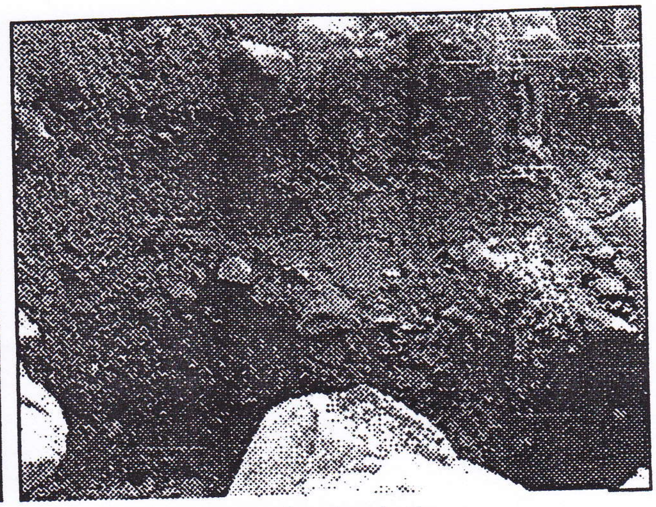

Photo 1. Photo show pyroclastic flows (piroclastic eruption) and its deposite is poorly sorted.

4.2. Sliding Direction and distance of the pyroclastic flows

In Merapi eruption history during century 20, direction of slide pyroclastic flows always show the change, where change direction this depended from morphology summit, form of aperture of crater structure looking like poultice of horse and position of lava dome. At this range of time direction the most slide pyroclastic flows is often happened up at west and southwest.

Distance of slide pyroclastic flows highly varied that is among1-12 km, so that Bronto, et all (1996) dividing distance of slide pyroclastic flows from source origin become 5 shares, that is distance very short (≤ 3 km), short (3-7 km), medium (7-10 km), long (10-15 km) and very long (> 15 km). Apart the longest slide pyroclastic flows during century 20 became of the year eruption 1930 entering K. Bebeng with the slide distance as far as 14 km.

5. Grain size analysis the pyroclastic flows

Grain size analysis done to 11 samples of sediment pyroclastic flows (Table 1) what is gone the round of slope Merapi by various variation of distance to eruption center. Sediment taken especially coarse sediment and lay in by river valley, as specially river valley in west slope Merapi. Sediment pyroclastic flows perceived to be done by analysis of distribution of grain size, statistical analysis of grain size covering mean, standard deviation, skewness and kurtosis. This analysis is also done by interpretation of distribution pyroclastic flows to distance from eruption center.

Table 1. Grain size analysis of pyroclastic flows

GRAIN SIZE	MESH	OPENING (MM)	SAMPLE (% WEIGHT) 1	2	3	4	5	6	7	8	9	10	11
GRANULE	5	4.000	24.24	23.43	22.55	30.07	25.14	69.96	29.77	37.75	32.96	16.93	24.04
	10	2.000	8.64	8.55	8.84	7.64	7.52	8.28	9.51	6.82	6.25	7.52	8.85
LAPILLI	18	1.000	16.90	12.49	20.02	13.19	11.58	7.62	13.50	11.45	11.31	12.36	12.75
	60	0.250	29.32	36.77	30.53	29.95	29.47	10.89	29.06	26.89	25.63	34.22	34.77
	120	0.125	9.69	12.05	8.07	8.54	11.91	1.97	9.16	9.10	9:19	15.25	11.44
ASH	270	0.053	9.42	5.75	7.44	8.79	11.19	0.96	6.78	6.85	12.07	10.92	6.52
	PAN	0.000	1.79	0.96	2.55	1.82	3.19	0.32	2.22	1.14	2.59	2.80	1.63
SUM			100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

5.1. Grain size of the pyroclastic flows

Result of analysis from 11 samples of sediment pyroclastic flows perceived to show, that in general variation of grain size of sediment pyroclastic flows is composed granule, lapilli and ash (see the Tables 2 and Figure 1). Grain size granule is bigger than 2 mm, lapilli is between 0.625 - 2 mm, while ash less than 0.625 mm. At grain size divisible lapilli become three grain size group (Tables 3 and Figure 1), that is coarse lapilli (0.5 - 2 mm), medium lapilli (0.25 - 0.5 mm) and fine lapilli (0.025 - 0.625 mm).

Table 2. Variation of grain size pyroclastic flows

GRAIN SIZE	SAMPLE (% WEIGHT)										
	1	2	3	4	5	6	7	8	9	10	11
GRANULE	32.88	31.98	31.39	37.71	32.66	78.24	39.28	44.57	39.21	24.45	32.89
LAPILLI	55.91	61.31	58.62	51.68	52.96	20.48	51.72	47.44	46.13	61.83	58.96
ASH	11.21	6.71	9.99	10.61	14.38	1.28	9	7.99	14.66	13.72	8.15
SUM	100	100	100	100	100	100	100	100	100	100	100

From variation of three the grain size, in general grain size of pyroclastic flows predominated by lapilli (20.48 - 61.83 %) followed by granule (24.45 - 78.24 %) and a few ash (1.28 - 14.66 %).

The proportion of variation lapilli is composed, proportion lapilli medium owning prosentase most dominant, that is about 10.89 - 36.77 %, when compared to by coarse proportion lapilli and fine grain.

Table 3. Variation of grain size lapilli

GRAIN SIZE LAPILLI	SAMPLE (% WEIGHT)										
	1	2	3	4	5	6	7	8	9	10	11
COARSE	16.9	12.49	20.02	13.19	11.58	7.62	13.5	11.45	11.31	12.36	12.75
MEDIUM	29.32	36.77	30.53	29.95	29.47	10.89	29.06	26.89	25.63	34.22	34.77
FINE	9.69	12.05	8.07	8.54	11.91	1.97	9.16	9.1	9.19	15.25	11.44
SUM	55.91	61.31	58.62	51.68	52.96	20.48	51.72	47.44	46.13	61.83	58.96

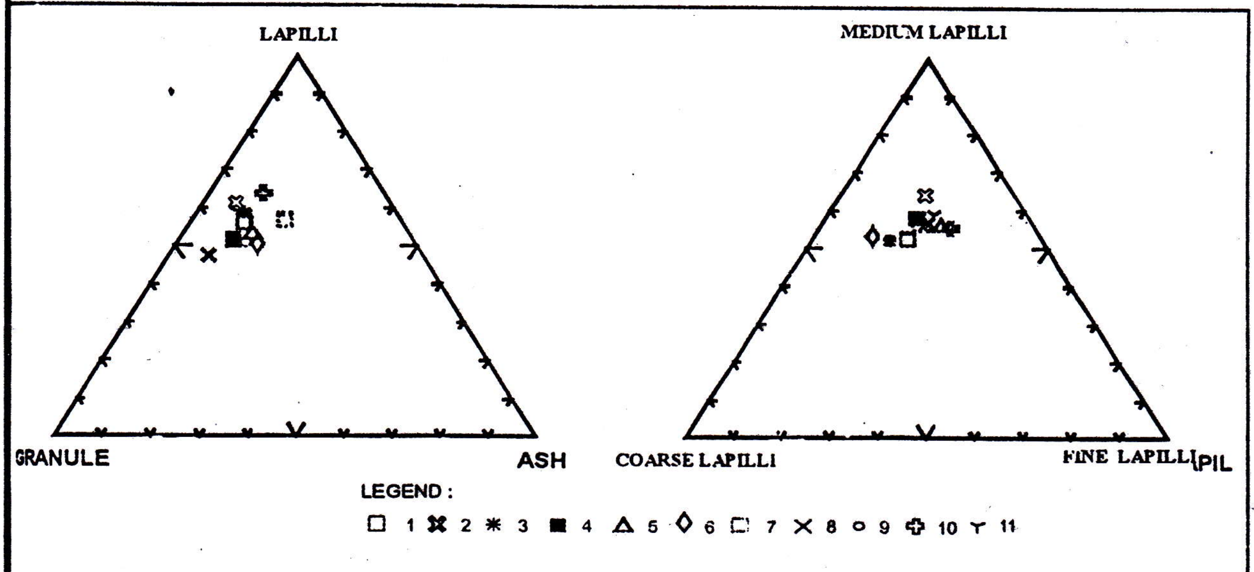

Figure 2. Variasi grain size of pyroclastic flows

Result of plotting of grain size (diamater mm) pyroclastic flows to % weight and presented in the form of graph Figure 3, in general indicate that the pyroclastic flows of Merapi have the blunt 2 pattern bimodal. This pattern gives the meaning that grain size of pyroclastic flows Merapi is very immeasurable or unsorted. The blunt pattern bimodal (A) deputized by samples of pyroclastic flows 1-5 and 7-11, looking item concentration incline up at softer item, while sample 6 representing blunt pattern bimodal (B) with the item concentration tend to incline at coarse grain.

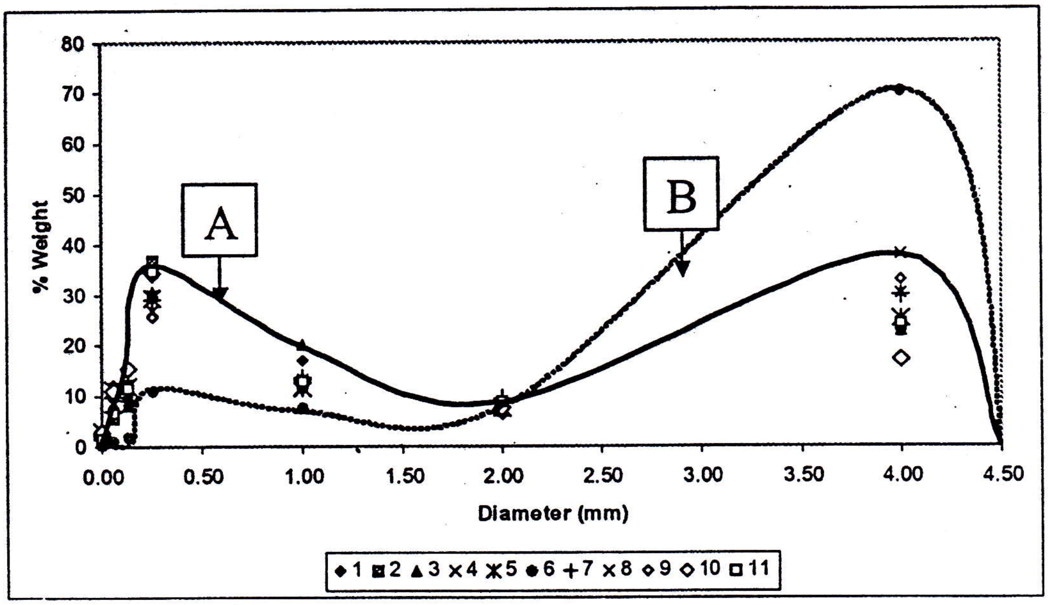

Figure 3. Graphic of grain size pyroclastic flows of Merapi

5.2. Grain size Statistic of the pyroclastic flows

Result of statistical analysis granulometry pyroclastic flows from to 11 samples pyroclastic flows taken show that grain size is unsorted, as drawn in distribution mean, standard deviation and skewness. As for clarification of concerning the statistical analysis can be followed as follows :

5.2.1. Mean distribution

Mean of grain size is represent the well-balanced comparison among weight grain with the activity of transportation. Transportation activity can be done by water and or wind. As graded bedding structure is gradually representing result from transportation process, where strength of material haulage vary.

The result of analysis mean of pyroclastic flows to 11 samples give the about -0.01 - 0.57. Negative value mean owned by sample 3, 4, 6, 7, 8 and 9, while positive value mean deputized by sample 1, 2, 10 and 11 (Table 4.).

Table 4. Distribution mean of piroclastic flows

SAMPLE	1	2	3	4	5	6	7	8	9	10	11
MEAN	0.02	0.03	-0.01	-0.16	0.22	-2.05	-0.23	-0.49	-0.09	0.57	0.03

Figure 4 is representing picture explaining to distribution of Merapi mean from pyroclastic flows samples. Grain of pyroclastic flows is progressively unsorted will have the ever greater value mean. Sample sediment 10 having biggest value mean (0.57) compared to the other sample. At sample 10, pyroclastic flows that is accomodated at mesh in proportion which is much the same (seeing Table 1). This matter give the meaning, that grain from the sample is very unsorted. While sample 6, having very low value mean (-2.05), the grain that accomodated at most at mesh 5 (69.96 %), seeing (Table 1). Compared to sample 10, hence sample 6 this own the grain size more unsorted.

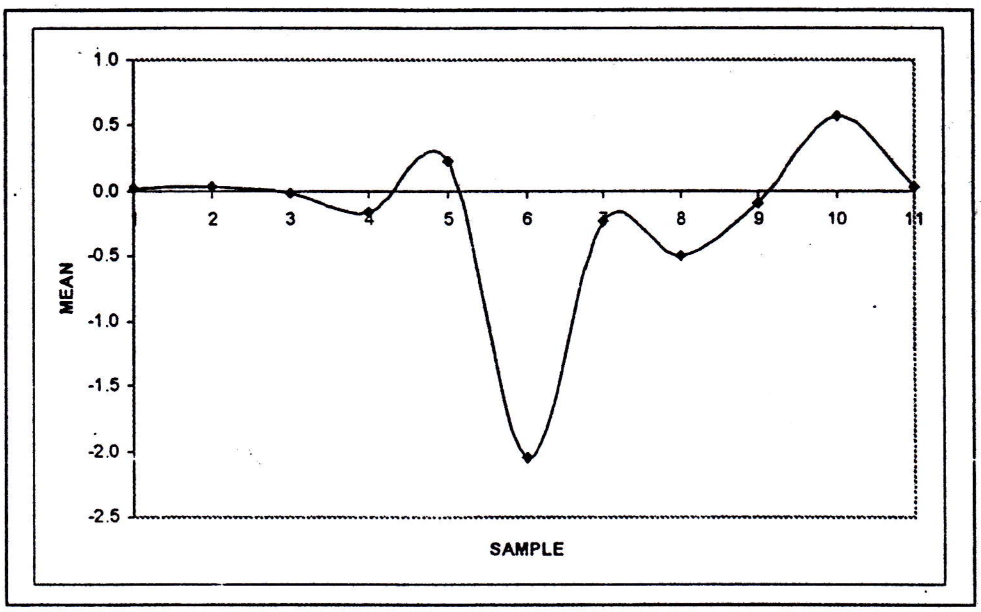

Figure 4. Graph of distribution mean of piroclastic flows

5.2.2. Distribution of Standard deviation

This standard deviation represent the measurement from sorting of grain. This sorting is happened by during process of transportation and precipitation. Process the selective dissociation will yield the very smooth grain. On the contrary process the abrasion will form the grain which unsorted. Interpretation of relation standard deviation by sorting at this writing follow the classification opened by Folk (1974) and visible at Table 5.

Table 5. Classification of relation standard deviation with sorting

Standard Deviation (sorting)	Verbal discription
< 0.35	Very well sorted
0.35 – 0.50	Well sorted
0.50 – 0.71	Moderately well sorted
0.71 – 1.0	Moderately sorted
1.0 - 2.0	Poorly sorted
2.0 - 4.0	Verv poorly sorted
> 4.0	Extremely poorly sorted

Standard deviation piroclastic flows have about 1.65-2.48 (seeing Table 5.). When relied on classification Folk (1974), is hence got by two type sorting of grain size, that is sorted very poorly and poorly. The grain more sorted show value of standard deviation which smaller. Sample with value of standard deviation about 2.10-2.48 giving meaning, that grain is very unsorted or very poorly sorting, but sample 6 has value of lowest standard deviation, that is 1.66. Distribution of pyroclastic flows show the grain distribution progressively coarse, but more compared to sorted of other sample.

Tabel 6. Relation ship of standard deviation and piroclastic flows sortation

SAMPLE	1	2	3	4	5	6	7	8	9	10	11
STANDARD DEVIATION	2.23	2.10	2.15	2.30	2.37	1.65	2.26	2.31	2.48	2.18	2.16
Sorting (Folk, 1974)	Very poorly	Very poorly	Very poorly	Very poorly	Very poorly	Poorly	Very poorly	Very poorly	Very poorly	Very poorly	Very poorly

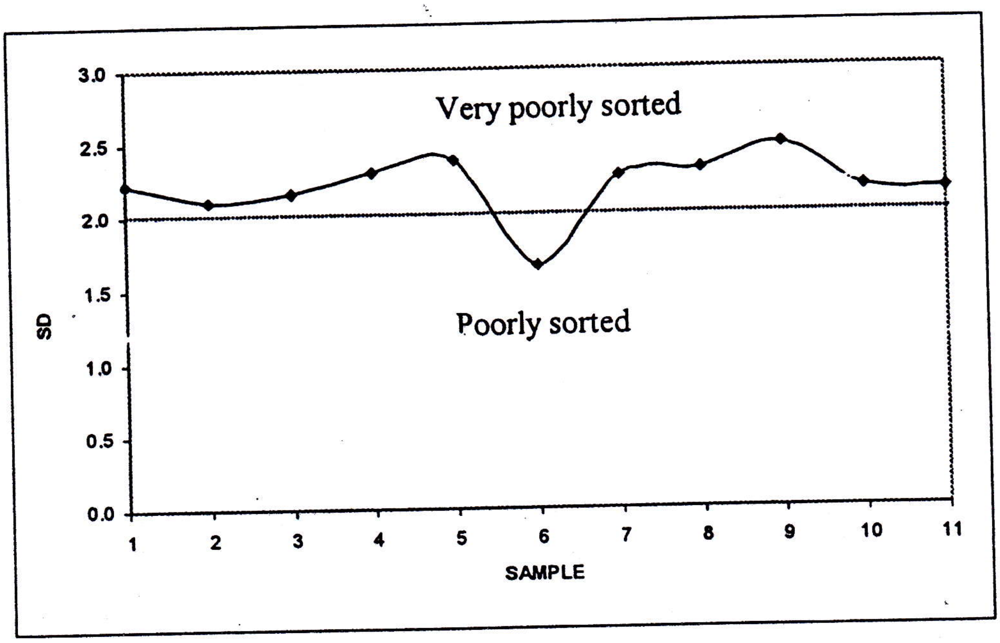

Figure 5. Graph of the relation ship standard of deviation (SD) and of pyroclastic flows sortation

5.2.3. Skewness

Distribution

Skewness	Verbal discription
1.0 - 0.3	Strongly fine skewed

Skewness is value of skew of distribution grain. Result of prediction skewness go together the precipitation environment, where the grain is precipitated. Positive value skewness (river sediment) representing reflection from variation of grain from coarse until fine, effect precipitation with the fickle current from strength become weak. Negative skewness show the record of fine grain, which is resulted from precipitation with the more constant wave or current. Prediction of relation standard deviation by sorting at this writing follow the classification opened by Folk (1974) and visible at Table 7.

Table 7. Classification skewness (after Folk,

0.3 - 0.1	Fine skewed
0.1 - - 0.1	Near-symetrical
- 0.1 - - 0.3	Coarse - skewed
- 0.3 - - 1.0	Strongly coarse-skewed

Value skewness of pyroclastic flows has range from -0.11-1.66 (seeing Table 8.). Discovered by 2 group value the skewness, that is positive and negative skewness. Negative skewness (-0.02 - -0.22) covering sample 2, 10 and 11. while positive skewness (0.09 - 1.66) taken possession by sample1, 3, 4, 5, 6, 7, 8 and 9. Group samples by negative skewness is interpreted, that in general grain of pyroclastic flows precipitated in more constant wave current mechanism and grain is softer, when compared to sample by positive skewness.

Table 8. Distribution skewness of pyroclastic flows

SAMPLE	1	2	3	4	5	6	7	8	9	10	11
SKEWNESS	0.09	-0.11	0.16	0.16	0.003	1.66	0.22	0.30	0.18	-0.22	-0.02
Skewness Folk (1974)	Near-symetrical	Coarse	Fine	Fine	Near-symetrical	Strongly fine	Fine	Coarse	Fine	Coarse	Near-symetrical

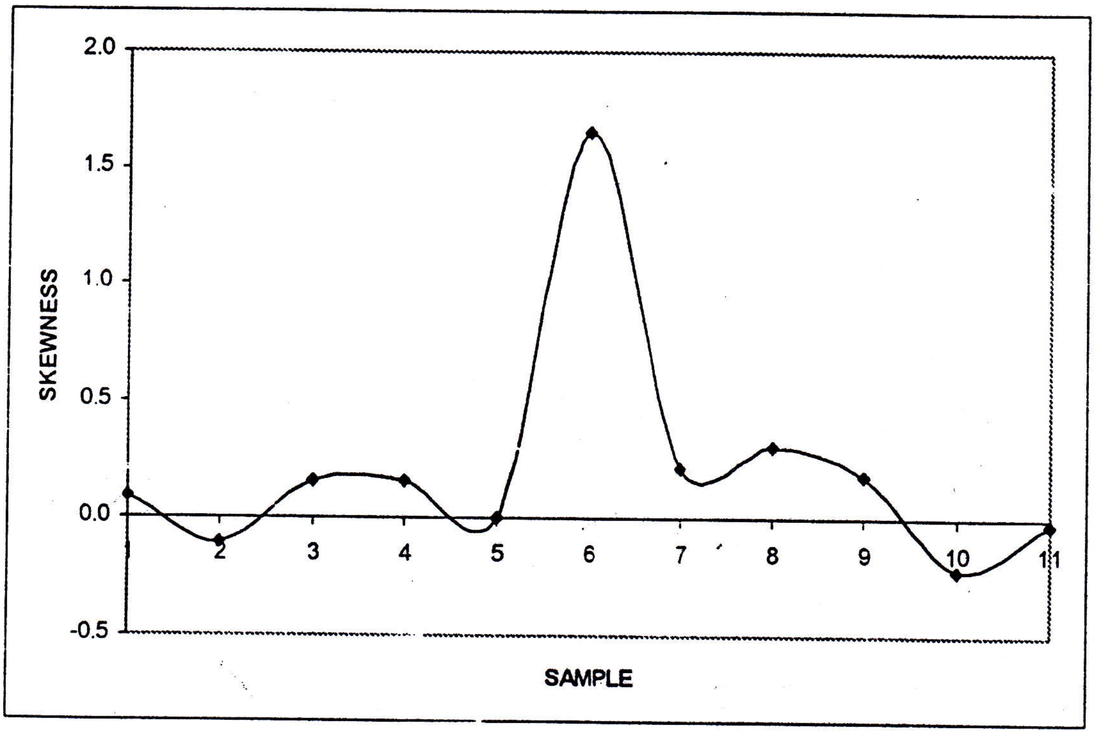

Figure 6. Graph of relation ship between skewness distribution and the current mechanism of sample pyroclastic flows

5.2.4. Variation of Standard deviation to skewness

Relation of sorting grain can learned from graph of result plotting standard deviation to skeweness (Figure 7). Sample with smaller standard deviation and value of skewness the ever greaterness, giving the meaning of that sorting is progressively good, although at sample 6 show the grain coarse progressively, but the grain which accomodated in mesh show more sorted, if compared to other sample (as sample comparator of sample 1) (seeing Figure 7. and 8.)

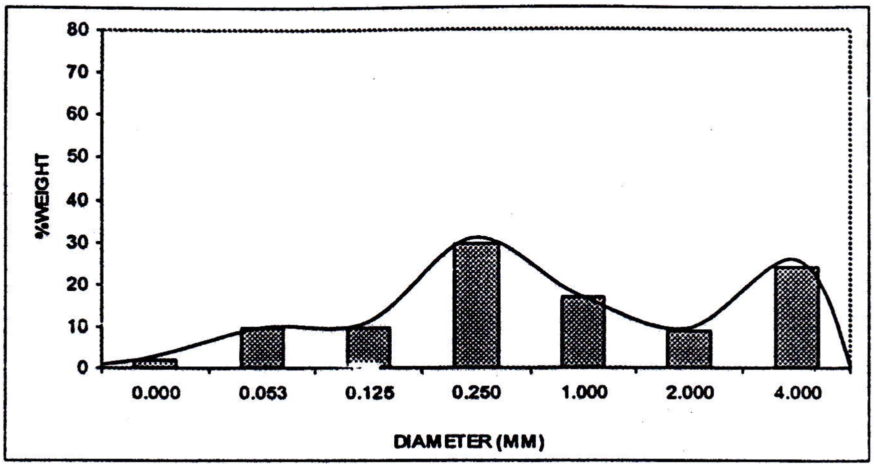

Figure 7. Histogram of sample 1of pyroclastic flows that show poorly sorted

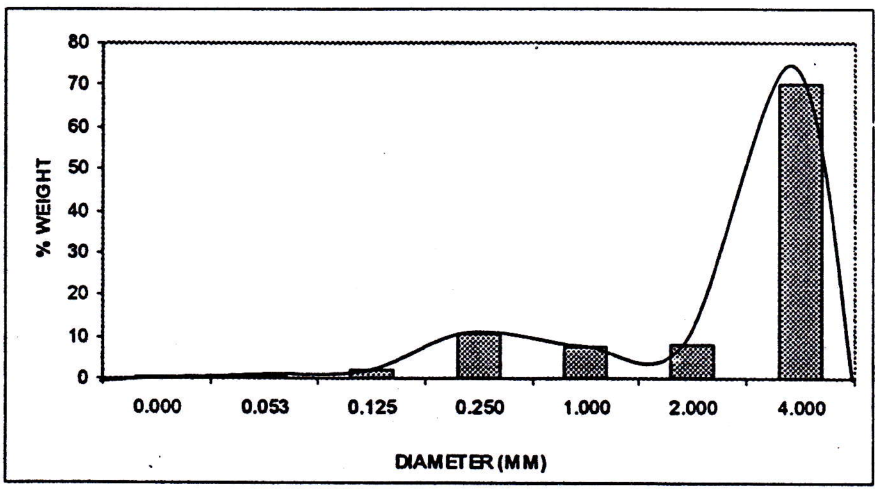

Figure 8. Histogram of sample 6 of pyroclastic flows that show more sorted than sample 1

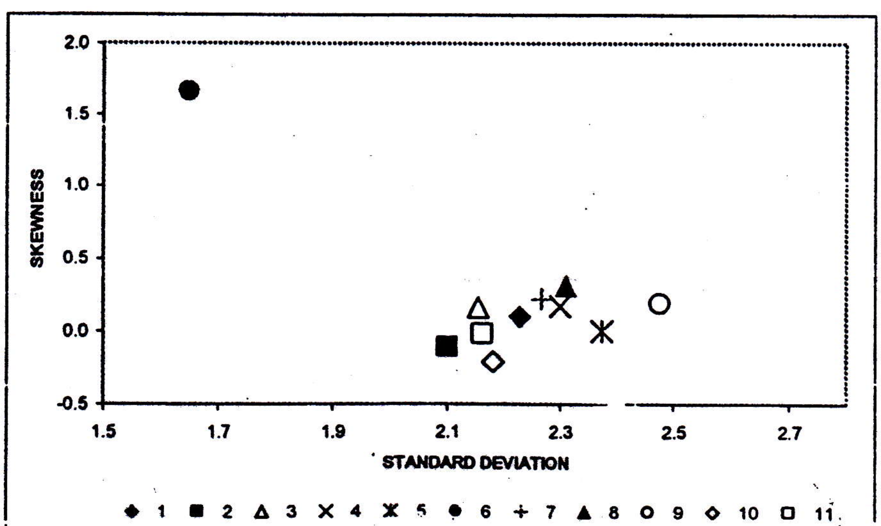

Figure 9. Relation of standard deviation and skewness pyroclastic flows

5.2.5. Distribution of pyroclatic flows to gliding distance

In this case to do the analysis of distribution of pyroclastic flows to distance glide, is hence selected by sample of found on same river valley or on the group same valleys. The mentioned done to see that by genesa of coarse grain piroclastic flows accumulate at the valley, so that sample taken to analyse selected is sample which is there are in same valley zone. Like sample 4 and 5 there are at valley K.Putih, while sample 6 and 7 there are in same valley zone K. Batang-Bebeng. Sample 9 and 10 are taking possession of valley K. Kuning. Some sample piroclastic flows done by this granulometry analysis have the distance from eruption center range from 3-4.5 Km (Figure 10.).

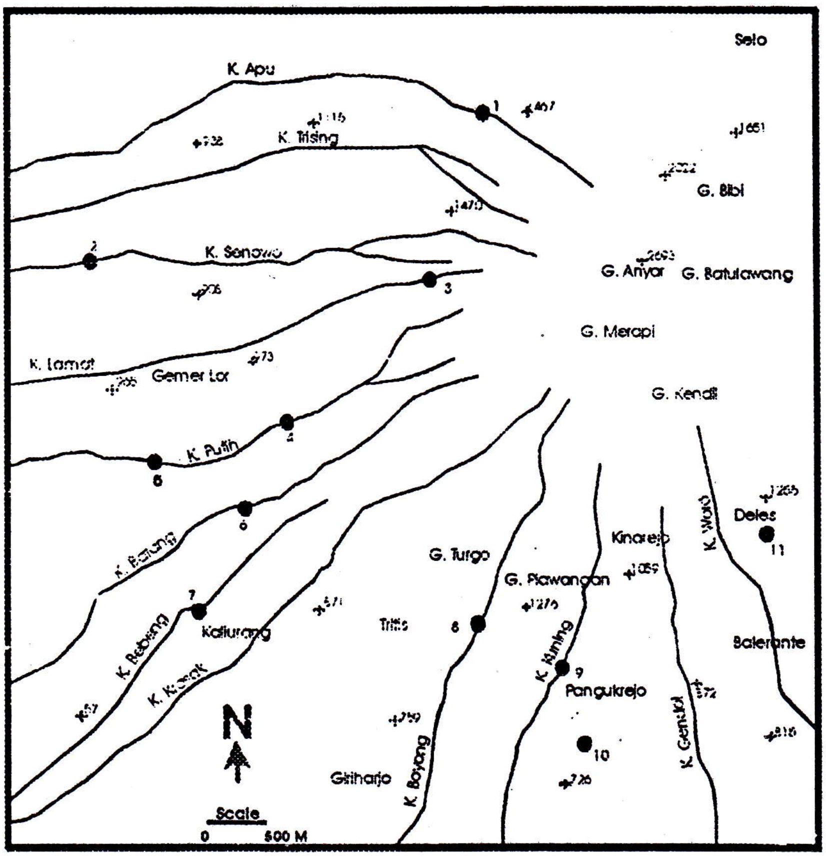

Figure 10. Location map of piroclastic flows sampling

Result analyse the distribution of pyroclastic flows to distance glide show that pyroclastic flows progressively far from eruption center have grain progressively fine. Like this as according to principle process sedimentation, that coarse grain will be precipitated beforehand or precipitated at nearer distance with the eruption center, when is compared with the softer grain. Percentage of granule show the content is decrease which progressively by increasing far it from eruption center. So far from the eruption center of Merapi fine grain proportion is progressively increase.This matter is followed also by its statistic analysis result, that is mean, standard deviation and skewness. Result of this analysis can be followed at Tables 9.

6. Conclusions

The result of granulometry analysis to 11 samples of pyroclastic flows around Merapi are as follows " :

- Type of grain of pyroclastic flows is granule, lapilli and ash. Lapilli (20.48 - 61.83 %) is taking possession of dominant procentage, and then followed by granule (24.45 - 78.24 %) and a few ash (1.28 - 14.66).
- Proportion of medium lapilli is most dominant about 10.89- 36.77 %, if compared to proportion of coarse and fine lapilli.
- Distribution grain pyroclastic flow show the composition grain unsorted and show pattern bimodal.
- The greater mean value show that the grain pyroclastic flows progressively is unsorted.
- Result of analysis to standard deviation yield two type of sorting of grain, that is very poorly and poorly sorted.
- The grain of pyroclastic flows that precipitated effect by more constant current have value of skewness negative or smaller. The grain will tend to fine, while valuable coarse is positive skewness
- The good sorted grain will have standard deviation smaller and value of skewness is greaterness. For example at sample 6, the grain most coarse, but showing more sorted, if compared the other sample.
- Progressively far from eruption center, the grain of pyroclastic flows is progressively fine. Percentage of coarse grain most decrease and then followed with improvement most fine grain.

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