PROCEEDING

The 2nd International Seminar of Basic Science

Natural Science For Exploration The Sea-Island Resources

Ambon, May 31st 2016

Organized by
Faculty of Mathematics and Natural Science
Pattimura University

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Mathematic and Natural Science Faculty
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2nd edition

Welcoming Address By The Organizing Committee

Today, We have to thank the The Almighty Allah SWT for the implementation of this international seminar. This is the second seminar about Basic Science in The Faculty of MIPA Pattimura University. The seminar under the title “Natural Sciences for Exploration the Sea-Island Resources” will be carried out on May 31st 2016 at Rectorate Building, Pattimura University. There are 200 participants from lecturers, research institute, students, and also there are 34 papers will be presented.
My special thanks refer to the rector of Pattimura University and the Dean of MIPA Faculty, Prof. Dr. Pieter Kakissina, S.Pd., M.Si. I also would like to express my deepest gratitude to Prof. Amanda Reichelt-Brushett, M.Sc., Ph.D. ; Kazuhiko Ishikawa, Ph.D. ; Nicolas Hubert, Ph.D. ; Prof. Dr. Kirbani Sri Brotopuspito ; Prof. Dr. Marjono, M.Phil. ; Gino V. Limon, M.Sc., Ph.D. as the keynote speakers.

The last, We hope this international seminar usefull for all of us, especially Mollucas People and very sorry if any mistake. Thank you very much.

Dr. La Eddy, M.Si.
Chairman of Organizing Committee

Opening Remarks
By Dean of Mathematic and Natural Sciences Faculty

I express my deepest gratitude to The Almighty God for every single blessing He provides us especially in the process of holding the seminar until publishing the proceeding of International Seminar in celebrating the 18th anniversary of MIPA Faculty, Pattimura University. The theme of the anniversary is under the title "Natural Sciences for Exploration the Sea-Island Resources". The reason of choosing this theme is that Maluku is one of five areas in Techno Park Marine in Indonesia. Furthermore, it is expected that this development can be means where the process of innovation, it is the conversion of science and technology into economic value can be worthwhile for public welfare especially coastal communities.

Having the second big variety of biological resources in the world, Indonesia is rich of its marine flora and fauna. These potential resources can be treated as high value products that demand by international market. Basic science of MIPA plays important role in developing the management of sustainable marine biological resources.

The scientific articles in this proceeding are the results of research and they are analyzed scientifically. It is expected that this proceeding can be valuable information in terms of developing science and technology for public welfare, especially people in Maluku.

My special thanks refer to all researchers and reviewers for your brilliant ideas in completing and publishing this proceeding. I also would like to express my gratefulness to the dies committee-anniversary of MIPA Faculty for your creativity and hard working in finishing this proceeding, God Bless you all.

Prof. Dr. Pieter Kakisina, S.Pd., M.Si.
Dean of Mathematic and Natural Sciences Faculty

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Hotel Mutiara Ambon

Contents

TEMPORAL STATISTICAL ANALYSIS OF THE VOLCANIC ERUPTION IN MT. BANDA API, BANDA ISLANDS, MOLUCCAS

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ABSTRACT

Mt. Banda Api (641 m) is a volcano islands located on 4°31'30 " S and 129°52'17" E. More than 27 eruptions have been reported since four of the last century. The volcanoes has the potential to cause natural disasters with the different intensity and power. Volcanic activity is a natural occurrence that is difficult to predict and may be considered as chaotic with no clear shape. Statistical methods can be applied to explain the pattern of volcanic eruptions as well as to help forecast future volcanic eruption activity. In this study, three temporal statistical methods was applied (Exponential distribution, Weibull distribution and Log-Logistic distribution). In general, the exponential distribution provides the highest probability of eruption that occurred within a specific time in the future with a 95% confidence level. In 2014, probability of eruptions in Mt. Banda Api is 49,16 %. Pattern of volcanic eruption in Indonesia are not normally distributed, so that the pattern of volcanic eruptions is a random. Qualitatively, the biggest eruption will follow the longest repose time interval. However, the magnitude of repose time no influence on the magnitude of VEI and doesn't affect to the probability of occurrence the volcanic eruptions. The average potential energy of the volcanic eruption in Mt. Banda Api period 1800-2013 amounted to 1,0195 x 10^{19} ergs and the average thermal energy of the volcanic eruption period 1800-2013 amounted to 2,0378 x 10^{21} ergs. Therefore, the total energy of the volcanic eruption in Mt. Banda Api amounted to 2,0479 x 10^{21} ergs.

Keywords: Mt. Banda Api, volcanic eruptions, VEI, repose time, exponential distribution, log-logistic distribution, weibull distribution, thermal energy, potential energy

INTRODUCTION

Mt. Banda Api (Figure 1) has a height of 641 m above sea level. The mountain is located in the district of Banda Island, Central Maluku, Maluku. Geographically is located at 4°31'30" S and 129°52'17" E. Mt. Banda Api arises from the north of a row of volcanoes located in the Banda volcanic arc (Van Bemmelen, 1949, p.219). Arc was formed approximately 1.5 million years ago.

The mechanism of complex formation is seen based on the theory of plate tectonics is the interaction between the main plate (Pacific and Indo-Australian plate) with multiple microplate well as the influence of transform faults and Irian faults causes the complexity of the region when viewed from the regional geological structure . These events causing the Banda arc and ocean regions as the source of tectonic earthquakes (PVMBG, 2014).

Figure 1. Mt. Banda Api (sumber : http://www.volcano.si.edu/volcano.cfm?vn=265090)

As a volcanic island, the potential danger of the eruption apart form the primary hazards such as falling throw pyroclastics (bombs and volcanic ash), pyroclastic flows (hot clouds), and lava flows, also potentially occur secondary hazards such as lava, eruption (phreatic) secondary to contact between the product volcanoes are still hot with sea water and volcanic avalanches likely to cause a tsunami.

Eruption of an island volcano like Mt. Banda Api often high risk and greater social impact for local residents than residents around the volcano in the area of land. Evacuation of the population at the time of the eruption has to do with the crossing of the volcanic island to another island that is considered more secure. Eruption in 1988, almost 8000 people were evacuated from the island of Ambon to Banda Islands and the island of Seram (Wahyudin, 2011).

TIME SERIES ANALYSIS ERUPTION at Mt. BANDA API

Based on the data recorded since 1500, Mt. Banda Api erupted more than 27 times (Badan Geologi, 1979). Only four events that cause the victim, in 1598, 1615, 1690 and 1988. The repose time ranged between 1-80 years. Variation of the repose time is generally proportional to the level of energy eruption that followed. If the repose time between eruptions is short, then energy that follow the eruption too small, otherwise if the repose time is long, then energy of the eruption that follow also great (Kirbani and Wahyudi, 2007).

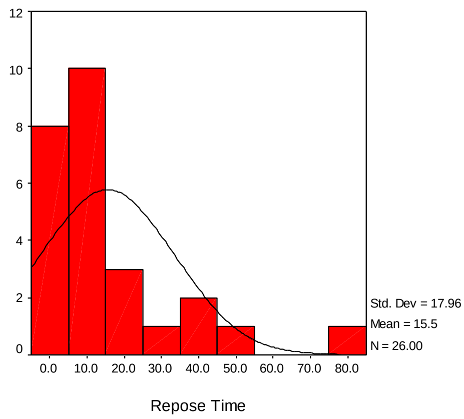

Figure 2. Histogram repose time on Mt. Banda Api

Figure 2 is a histogram above shows the time series of repose time at Mt. Banda Api start in 1586 until 1988. From the histogram above, the mean of repose time on Mt. Banda Api of 15,5 years. This does not mean that every 15 year eruption may occur. Based on Table 1, the size of skewness is 2,269, then the ratio of skewness is 4,98 while the kurtosis measure is 5,96, then the ratio of kurtosis was 6,72.

TAbel 1. Statistik repose time on Mt. Banda Api

Statistics

Repose

N	Valid	26
	Missing	0
Mean		15.46
Std. Deviation		17.96
Variance		322.66
Skewness		2.269
Std. Error of Skewness		.456
Kurtosis		5.960
Std. Error of Kurtosis		.887

Statistically, the distribution of time series of volcanic eruptions can be expressed as an exponential distribution (Wickmann, 1965),

$$N(\lambda, \tau) = N_0\left(e^{-\lambda\tau}\right) \qquad (1)$$

where,

N = count eruptions that have longer the repose time than t
N_o = count eruptions that have longer the repose time than 0 years
τ = repose time
λ = exponential attenuation coefficient

Value of λ for the eruption of Mt. Banda Api is 0,0647 / year. Exponential distribution (1) has a medium value (*T*, mean value) 1 / λ, in terms of time series of volcanic eruptions can be referred to as the mean eruption repose time. *T* for Mt. Banda Api with λ = 0,0647/year amounted to 15,5 years. This does not mean that every 15,5 years always eruption, so wrong if *T* is said to be the return period. The events that have exponential Poissonian distribution is essentially random.

Time series of volcanic eruptions has a probability density function / PDF (Wickmann, 1966) wasn't the eruption,

$$\text{PDF No Eruption } (\lambda, \tau) = \lambda\tau\left(e^{-\lambda\tau}\right) \qquad (2)$$

Not eruption PDF function (λ, *t*) can be categorized as a Poissonian distribution function. Eruption PDF function can be formulated as follows:

PDF Eruption (λ, τ) =1- $\lambda\tau\left(e^{-\lambda\tau}\right)$ (3)

Based on table 2, Mt. Banda Api has τ = 86 year, so has the probability of eruption at 18,6 %.

Based on probability of eruption Mt. Banda Api is 18,6 %, so this time there is a value at risk can not be ignored, so there is no other way but to no mitigation measures that minimize negative impacts caused by the eruption of Mt. Banda Api.

Tabel 2**.** The probability eruption of Mt. Banda Api

Distribusi	**Probabilitas erupsi (2014)**
Eksponensial	18,6 %
Weibull	26,17 %
Log-Logistik	49,16 %

Weibull Distribution

It may be argued on physical grounds that the hazard rate should bellowed to systematically increase / decrease with time to includegimes of increasing volcanic activity or waning/extinguishing activity. This can be accomplished by the Weibull distribution, commonly used in failure analysis and successfully applied to various volcanoes (Ho, 1991; Bebbington and Lai, 1996a, b ; Watt et al. , 2007):

$$S_{WB}(t) = exp\{-(\lambda t)^{\alpha}\} \qquad (4)$$

where α is a power parameter, usually referred to as the “shape parameter”. For α = 1, the Weibull distribution includes the exponential distribution as a special case, but it also accommodates the possibilities of increasing or decreasing hazard rates if α>1 or α<1, respectively. As the Weibull distribution represents a model of simple failure, it best illustrates scenarios that consider this failure after a given time as a result of only one dominant process in the system. In 2014, the eruption of Mt. Banda Api has a probability of 26,17 % (Table 2).

Log-Logistic Distribution

A certain parameters can increase the likelihood of eruption, while other parameters will cause a decrease in the probability of an eruption. Factors that influence can be formulated with a log-logistic distribution (Dzierma and Wehrmann, 2010):

$$S_{log}(t) = \frac{1}{1+\left({}^{t}/_{b}\right)^{\alpha}} = \frac{1}{1+(\alpha t)^{\gamma}} \qquad (5)$$

which includes a scale parameter b and a shape parameter α. A log–logistic distribution can sometimes achieve a better fit particularly to very long or short repose intervals (Connor et al., 2003). In 2014, the eruption of Mt. Banda Api has a probability of 49,16 % (Table 2).

Correlation Analysis Between Repose Time and VEI

Qualitatively, the largest eruption will follow the longest rest interval greater than 100 years (Simkin and Siebert, 1984, 1994). Variations of repose time are generally comparable to the energy level of the eruption that followed. If the short repose time between eruptions, the eruptive energy usually follow it too small, otherwise if the long repose time then the energy of the eruption that followed was also large. This is caused by the accumulation of energy in a relatively long time. Repose time and magnitude of eruptions during the eruption process is fundamentally different because the controlling behavior during the active growth phase of a volcano tends to have a long repose time. Correlation repose time and VEI Mt. Banda Api is shown in Figure 3.

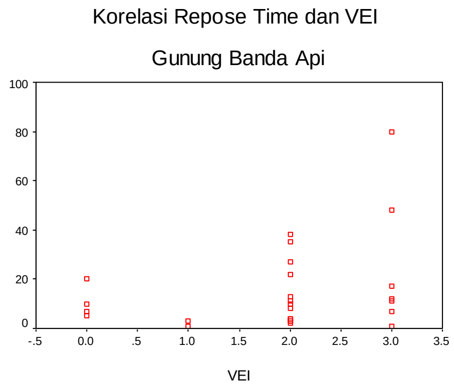

Figure 3. Correlation repose time and VEI Mt. Banda Api.

To find out more about the correlation between repose time with VEI at Mt. Banda Api using SPSS.

Tabel 3. The results correlation analysis between repose time and VEI on Mt. Banda Api

	R	Sig. (2-tailed)
VEI	0,301	0,135
Repose Time	0,301	0,135

According to Table 3, the significance of the results of the correlation between repose time with VEI magnitude of 0.135 (> 0.05) then H_o is accepted. This shows that the repose time does not affect with the VEI. The correlation coefficient between repose time and VEI is positive, which means that the greater the repose time the index VEI greater. The correlation coefficient is 0.301 magnitude whose value is much smaller than 1 (perfect correlation coefficient). This is shows the weak relationship between the two variables. From the above results it can be concluded that repose time no effect on the VEI. This can be affected by several other factors such as differences in chemical composition both before and after the eruption,topography,morphology, characteristics of volcanoes, etc.

Potential Energy and Thermal Energy of Volcanic Eruption on Mt. Banda Api Period 1800-2013

Yokoyama (1956) estimate the energy at the time of volcanic eruptions are divided into various forms such as potential energy and thermal energy. The potential energy is represented by changes in the level of lava in the hole / vent volcano during an eruption. Energy eruptions can be formulated as follows:

$$E_p = mgh \qquad (6)$$

where,

Ep = potential energy (Joule)
m = total mass of materials eruption (kg)
g = acceleration of gravity (m/s^2)
h = high column of smoke when the eruption (m)

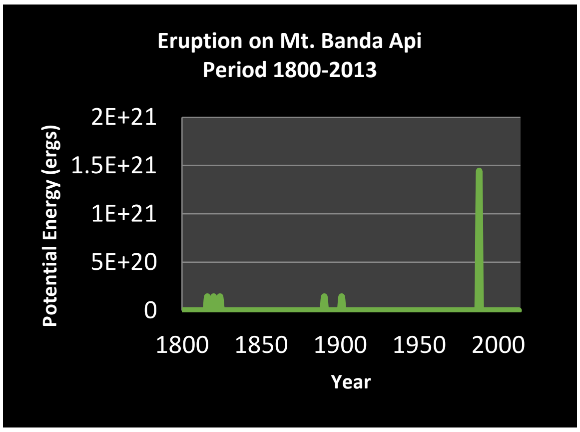

Figure 4. Eruption on Mt. Banda Api (1800-2013)

During the period 1800-2013 eruption, Mt. Banda Api generate the potential energy of 1,0195 x 10^{19} ergs. Figure 4 shows the eruption of Mt. Banda Api periodicity of 1800-2013. In the picture looks the pattern eruption on Mt. Banda Api.

Thermal energy is represented by the quantity of hot lava and gases from volcanic fragments respectively. The equation used by Yokoyama to high temperatures> 1000 ° C as follows:

$$E_{th} = V\sigma(T\alpha + \beta)J \qquad (7)$$

where,
E_{th} = thermal energy
V = ejecta volume
σ = the mean of density
T = lava temperature
α = specific heat lava (when T=800 ^{o}C, α=0.25 cal/gr.^{o}C and when T=300 ^{o}C, α=0.20 cal/gr.^{o}C)
J = work equivalent of heat, 4.1855 x 10^7 ergs

During the period 1800-2013 eruption, Mt. Banda Api generates the thermal energy of 2,0378 x 10^{21} ergs. Therefore, the total energy of the eruption of Mt. Banda Api from 1800 to 2013 amounted to 2,0479 x 10^{21} ergs.

CONCLUSION

The time series eruption on Mt. Banda Api has the characteristics of stochastic random, with count eruption as a function of repose time have an exponential distribution and PDF Poissonian function with the attenuation coefficient is equal to 0.0647 or medium repose time value of 15,5 year. The probability of eruption on Mt. Banda Api in 2014 based on the exponential distribution by 18,6 %. Weibull distribution gives the probability of eruption at 26,17 % while the Log-Logistic distribution gives the probability of eruption at 49,16 %. Volcanic eruption probability > 50%, so it needs to be aware of risk that must be borne. Eruption of Mt. Banda Api during the period 1800-2013, generate an average potential energy of 1,0195 x 10^{19} ergs and the average thermal energy of 2,0378 x 10^{21} ergs. Therefore, the total energy of the eruption of Mt. Banda Api from 1800 to 2013 amounted to 2,0479 x 10^{21} ergs.

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