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SEISMISITY AND ENERGY EARTHQUAKE IN AMBON ISLAND 1967-2017 ($3{,}5^{O}$ LS - $3{,}8^{O}$ LS and 127,9 BT – 128,4 BT)

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ABSTRACT

The energy emitted as waves is a very important parameter for understanding the physics of a ruptured earthquake. This energy calculation, however, is difficult and is forged with uncertainty. We use this method to calculate b-value, emitted wave energy and seismic moment energy for 77 earthquakes with magnitude ranging from 2 to 6 and with a depth of 0 to 400 km. The purpose of this research is to analyze seismicity and earthquake energy in Ambon Island and its implications for future earthquakes using b as the precursor. Statistical data for earthquakes that are earthquakes with magnitude ranging from 2 to 9 and with a depth of 0 to 400 km. Furthermore the data is analyzed by Maximum likelyness method using the equation given Utsu and empirical formula from Gutenberg and Richter. The incidence of earthquakes has increased over the last 50 years. After the earthquake in 2005 the increase in the earthquake incidence is increasingly sharp. This is done by the process of achieving the energy that occurs by the plates, which occur after the successive earthquakes to the energy node in three different locations, Location 1. Hatu-Alang, Location 2. Mamala-Morela and Location 3. Wai -Tulehu. The value of the constant b value of earthquakes in Ambon Island is low, ie 0.267 and. These values represent high levels of stress, and most likely large earthquakes will occur again on Ambon Island. Seismic energy in waves from Earthquake Source has the greatest value of 1.12202E + 13 J and the seismic moment energy has the

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greatest value 2.192805E + 17 J with magnitude 5.5 SR is located to the south of the island precisely the village of Allang.

INTRODUCTION

The Indonesian archipelago is equipped in the third round of the world, the Indo-Australian Plate, the Eurasian Plate, and the Pacific Plate. This causes Indonesia to be included in areas with high earthquake potential, more than 14,000 earthquake events that occurred in Indonesia since 1900-2000. One area in Indonesia that can be spelled out has a high potential earthquake is Eastern Indonesia, including the Moluccas [1],[17]. At this stage of research is devoted to the island of Ambon.

Ambon Island is included in the tectonic zone complex, because it is a meeting of three plates namely the Eurasian plate, the Pacific plate, and the plates Philippines, as well as on the northern part of Seram Island boundary zone of Indo-Australian plate subduction. By tectonic and geological conditions, the region is affected by subduction of Banda Arc in the north, thrust of the Seram Sea at south, subduction of Moluccan Sea plate, and Sula Sorong fault in the south. Recorded more than 77 earthquake events the earth starts from January 1967 until December 2017 which can be recorded by the earthquake recording station. From the potential for frequent earthquakes, the need for study seismicity in the form of earthquake energy as an effort disaster mitigation.

In Maluku studied the probabilities for large subduction earthquakes based on over 50 years of historical records that included M 2 - M5 class events in this region (Fig. 1).

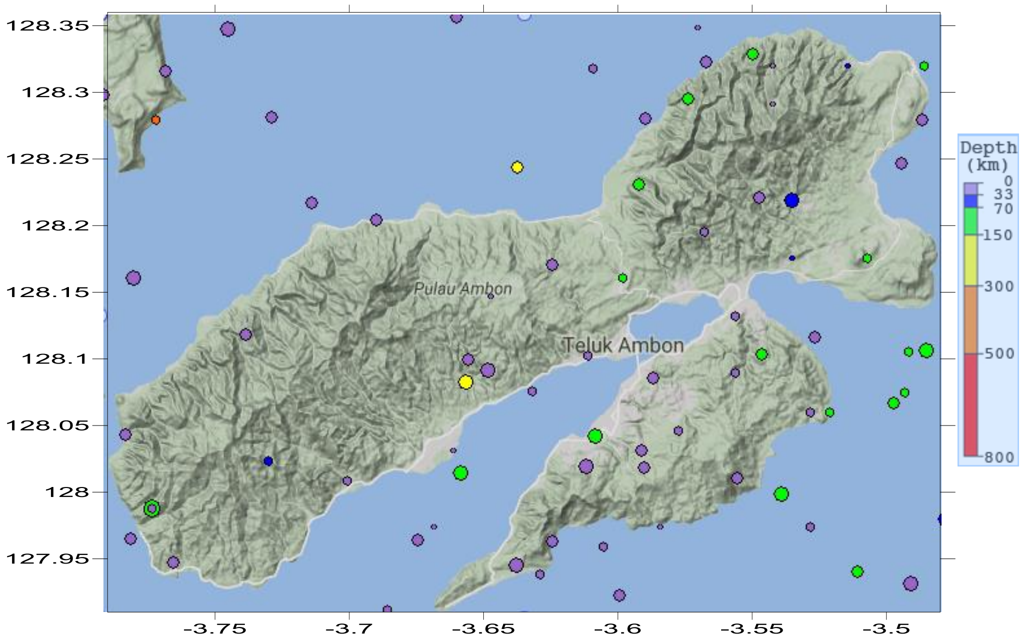


Figure 1. Map of Seismicity of Ambon Island in 1967-2017 (see catalog of historical events at see https://www.iris.edu/hq/#).

BASIC THEORY

Seismisity

Earthquakes caused by self-organized criticality like avalanches often generate anomalous energy release within narrow spatial-temporal intervals. Patterns of spatial, temporal and magnitude distribution of earthquakes have been the focus of many studies and been used as the main attributes involved in models for prediction. It has been demonstrated that the energy release by earthquakes follows power-law relations with accumulative time, scale of space and frequency of earthquakes. For example, the relationship between the accumulative number of earthquakes N(>M) with magnitude greater than M can be expressed as the Gutenberg-Richter relation [4].

Seismicity is a seismic activity (earthquake) or earthquake over a period of time. Study the seismicity pattern of ways to find suitable seismic activity patterns over a fairly long period. Methods to determine seismic and tectonic parameters are with Gutenberg-Richter or magnitude-frequency relation (MFR) relationships are written as [3]:

$\log n(M) = a - bM$ (1)

with n (M) is the number of earthquakes with magnitude M. a-value is a seismic parameter whose magnitude depends on the number of earthquake events and for a particular region depending on the determination of volume and time window. The b-value (usually close to 1) is a tectonic parameter showing the relative amount of small and large vibrations. The b-value can be determined by least square or maximum likelyness method. Maximum likelyness method using the equation given Utsu is [16]:

$b = \log e/(M - Mmin) = 0{,}4343/(M - Mmin)$ (2)

With M is the average magnitude and $Mmin$ is the minimum magnitude.

The last few decades, seismologists have developed models to characterize the earthquakes in the context of plate coupling strength [6],[7],[9],[10]. A systematic study that examined historic and recent seismicity data presented a hypothesis on the correlation between intraplate seismicity and large interplate earthquakes, and suggested the possibility of a large interplate event [12]. However, it has not yet been clarified if this region of the subduction zone was accumulating stress in a strongly coupled state or slipping more aseismically in a weakly coupled state [5],[8], [13],[14],[15].

Earthquake Magnitude and Seismic Moment

In the Gutenberg-Richter Formula, energy can be determined by using the input parameters of magnitude through the equation: log Es = a + b M, where a and b are constants. Based on the formula of Choy and Boatwright [2] the energy equation is [4]:

$\log Es = 4.4 + 1.5\, Ms$ (3)

in which Ms forms the surface wave magnitude.

The magnitude conversion equation of m, mb, Ml becomes Ms based on Ambrasseys (1990) as follows [4]:

$m - 2{,}5 = 0{,}63\, Ms$ (4)

$0{,}86\, mb - 1{,}94 = 0{,}49\, Ms$ (5)

$0{,}80\, Ml - 1{,}04 = 0{,}6\, Ms$ (6)

Specifically, moment magnitude relates to the amount of movement by rock; i.e. the distance of movement along a fault or fracture and the area of the fault or fracture surface. It is calculated as

$M_O = \hat{A}\mu AD$ (7)

Where: Âµ is the shear modulus of the rocks included in the fault (dyne/cm^2), A is the area of the fault rupture in cm^2, D is the average fault displacement in cm dan M_O is shown in units of energy, dyne-cm. Both the earthquake magnitude and the seismic moment are related to the amount of energy that is radiated by an earthquake. Richter, working with Dr. Beno Gutenberg, developed a relationship between magnitude and energy. That relationship is [4] :

$\log E_S = 11.8 + 1.5M$ (8)

giving the energy E_S in ergs from the magnitude M.

Note that E_S is not the total "intrinsic" energy of the earthquake, transferred from sources such as gravitational energy or to sinks such as heat energy. It is only the amount radiated from the earthquake as seismic waves, which, as was said above, is in most cases only a small fraction of the total energy transferred during the earthquake process.

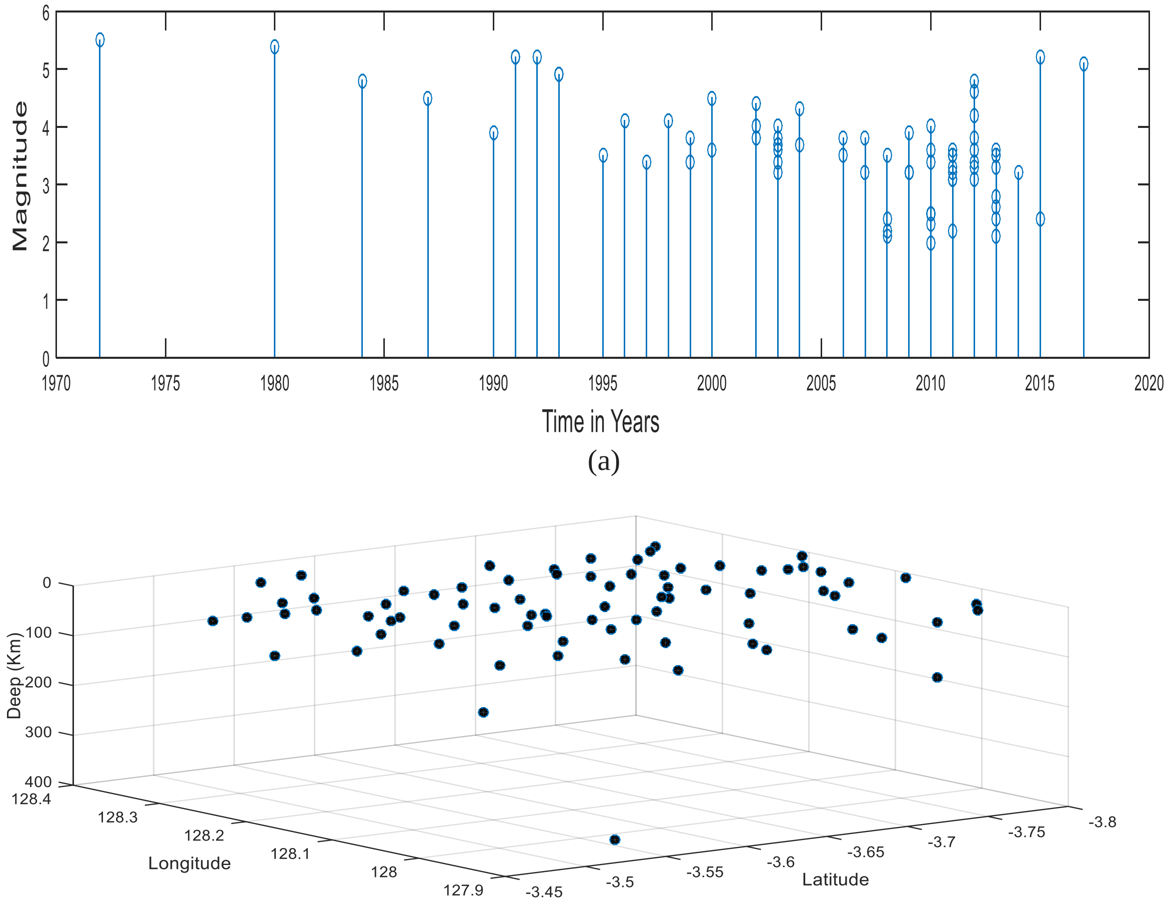
METHODS

This study uses earthquake IRIS earthquake data with period 1967 - 2017. Limitations of research area 3,5^O LS - 3,8 ^{O} LS to 127,9 BT – 128,4 BT. The number of earthquake data used as many as 77 earthquake events. The b-value can be determined by least square or maximum likelyness method. Maximum likelyness method using the equation given Utsu. Furthermore the data is copied by statistical methods with empirical formulas from Gutenberg and Richter.

RESULT AND DISCUSSION

Earthquake Magnitude

The epicenters of earthquakes used in this study at Ambon Island are shown in Fig.2. A catalog composed of 77 events with local magnitude ranging from 2 to 5.5 is used in this study. The range of focal depth for these. An earthquake with magnitude M3.8 has a return period of 2 to 13 years While an earthquake with magnitude M5.2 (Figure 2a) has a return period of about 1 to 25 years with a short period of possibilities going around the Maluku sea. The likelihood that a quake returns in the short period of an earthquake is highly correlated with the high parameter value .a-b.



(a)

(b)

Figure 2. (a) Plot of magnitude of current events as a function of time and (b) view map of events as a function of depth.

Variations of b-value

The pictures show that Ambon Island has been hit dozens of times earthquakes ranging from small earthquakes to large. Areas that have high seismic activity are generally located in the western region, north to east. While southern and southeasly activities of the amount of earthquake data that is as much as 77 earthquake events. From the data then dilakuan b-value calculated with equation 2 which shows that the average b-value on the island ambon about 0.267 and a value of about 7.425.

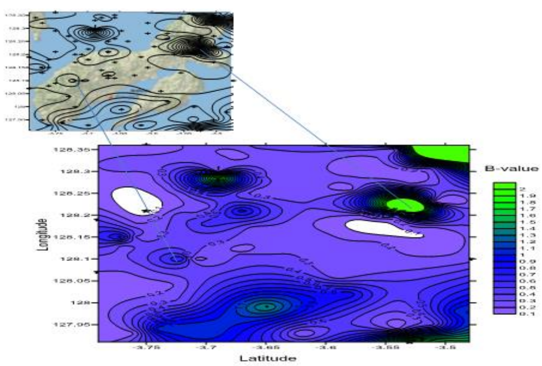


Figure 3. Map of Variation b-value of Ambon Island Year 1967-2017

(Figure 3). This value indicates that the existing seismograph network is only able to record the earthquake on the magnitude well. The spread of b-value can be found in several locations on Ambon Island, around Wai, Tulehu, Liang, Hatu, Allang, Peninsula Lei Hittu and Amahusu vilages.

From some map plots of mgnitudo of the Ambon Island earthquake and the b-value map found short repetition periods potentially occur in the eastern region such as Wai Village and Tulehu Village, then shifted from north to west of Peninsula Leihitu and south direction of Amahusu village. The area that has a short re-period is a region that has high seismic activity, meaning that earthquakes in this region are generally dominated by small magnitudes of earthquakes to moderate. So by knowing the areas that have this short period so that can be wary of the threat of moderate earthquakes to big.

This low b value also indicates that it is likely that moderate to large earthquakes are most likely due to high stress levels. In contrast the high b value ($b \geq 2$) is found around the Seram Sea and Banda Sea which is usually correlated with the increasingly homogeneous. In addition, the high value of b according to some experts correlates with the points of fire / melting point which is the geothermal area (Wandono, 2004). This is evidenced by the magnitude of b-value around the village of Wai and Tulehu vilages dengan b-value 1.6-1.8.

Seismic Energy in Waves Radiated from Earthquake Source

The energy radiated as waves is a parameter vital to the understanding of earthquake rupture physics. Calculations of this energy, however, are difficult and wrought with uncertainty. The method calculates these parameters in an internally consistent and objective manner, allowing for robust comparison between parameters and across earthquakes.

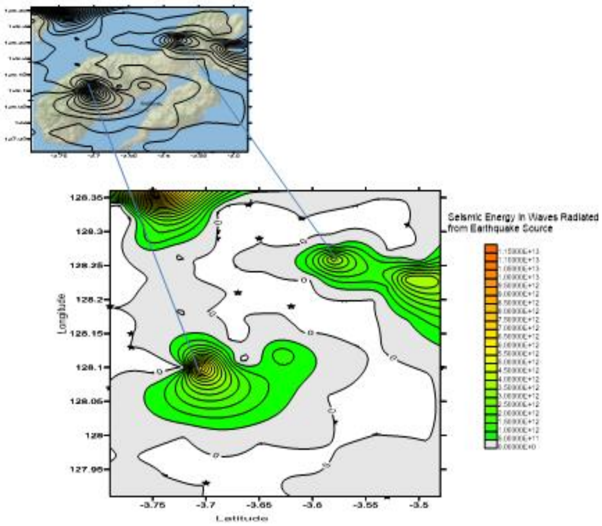


Figure 4. Map of Variation Seismic Energy in Waves Radiated from Earthquake Source of Ambon Island in 1967-2017.

Based on Figure 4. Seismic energy distribution in Waves Originating from Earthquake Source spread in three different locations. Location 1 in Hatu-Allang villages south west of Ambon island, Location 2 is located in the village around Mamala-Morela north east of Ambon island, and Location 3 is east of Ambon Island around Wai-Tulehu village. Seismic energy in wave derived from Earthquake Source has the greatest value 1.12202E + 13 J with magnitude 5.5 SR is located south of the islands precisely the village of Allang.

Seismic Moment Energy

The seismic moment of an earthquake is typically estimated using whatever information is available to constrain its factors. For modern earthquakes, moment is usually estimated from ground motion recordings of earthquakes known as seismograms. For earthquakes that occurred in times before modern instruments were available, moment may be estimated from geologic estimates of the size of the fault rupture and the slip.

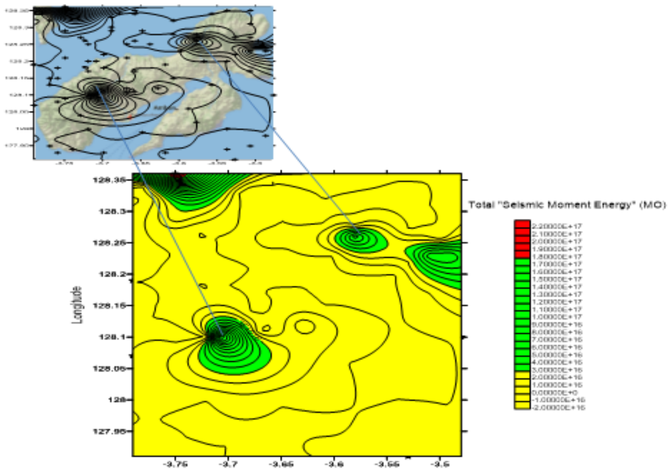


Figure 5. Map of Variation Seismic Moment Energy of Ambon Island in 1967-2017.

Seismic moment is the basis of the moment magnitude scale which is often used to compare the size of different earthquakes and is especially useful for comparing the sizes of large (great) earthquakes. Based on Figure 5. Seismic Moment Energy of Ambon spread in three different locations. Location 1 in Hatu-Allang villages south west of Ambon island, Location 2 is located in the village around Mamala-Morela north east of Ambon island, and Location 3 is east of Ambon Island around Wai-Tulehu village. Seismic Moment Energy has the greatest value 2.192805E+17 J with magnitude 5.5 SR is located south of the islands precisely the village of Allang.

CONCLUSION

1. The result of seismicity data obtained by the average b-value in Ambon Island from 1967-2017 was 0.267 and the averaged a-value was 7.425. This is evidenced by the magnitude of b-value around the village of Wai and Tulehu vilages with b-value ranging from 1.6 to 1.8.

.2. Seismic energy distribution in waves originating from earthquake source and seismic moment energy spread in three different locations. Location 1 in Hatu-Allang villages south west of Ambon island, Location 2 is located in the village around Mamala-Morela north east of Ambon island, and Location 3 is east of Ambon Island around Wai-Tulehu village. Seismic energy in wave derived from Earthquake Source has the greatest value 1.12202E + 13 J and seismic moment energy has the greatest value 2.192805E+17 J with magnitude 5.5 SR is located south of the islands precisely the village of Allang.

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