

## Study Seismotectonic Around Kalimantan Island Using Likelihood Method

Iyan Haryanto<sup>1</sup>, Lisa Lamba<sup>2</sup>, Shinta Ayu<sup>2</sup>, Edy Sunardi<sup>1</sup>

<sup>1</sup>Departement of Geoscience, Faculty of Geological Engineering, Padjadjaran University

<sup>2</sup>Faculty of Geological Engineering, Padjadjaran University

Corresponding author: [shinta18001@mail.unpad.ac.id](mailto:shinta18001@mail.unpad.ac.id)

### ABSTRACT

*Based on Indonesia Seismicity Map and Indonesia Seismotectonic Unit Map (Geological Research and Development Center, 2003), it can be seen that the Kalimantan Island area has the lowest earthquake vulnerability compared to other regions in Indonesia. However, in past recent years, there have been several destructive earthquakes occur in this area. As it occurred on June 5, 2015, in Ranau area with a magnitude of 6, on December 21, 2015, in Tarakan area with a magnitude of 6.1, on June 24, 2016, with a magnitude of 5.1, on 25 February 2015 with a magnitude of 5.7 in the northeast of Tarakan and 12 July 2018 in Katingan with a magnitude of 4.2. This indicates that the possibility of a potential earthquake in the Kalimantan area can still occur. For this reason, it is necessary to identify seismotectonics and the recurrence period to ensure the potential for earthquake hazards on the Island of Kalimantan. The likelihood method is used to calculate those parameters with earthquake data from 2009-2020 with a magnitude  $\geq 5$  and a depth of 0 – 350 Km sourced from the Meteorology, Climatology and Geophysics Agency (BMKG). Based on the calculation results, it is obtained that the value of  $a$  is 2.71222 and the value of  $b$  is 0.64077. In general, it can be concluded that the seismicity level of Kalimantan Island is quite low.*

**Keyword:** Seismotectonic, Kalimantan Island, Seismicity index, likelihood method

### INTRODUCTION

Indonesia has long been known as one of the countries with a complex tectonic order due to the meeting of 3 large plates. This tectonic plate activity has an impact on the presence of volcanoes and the occurrence of earthquakes in this area. However, what is interesting is that when almost all parts of Indonesia are frequently shaken by earthquakes, it can be seen that the Kalimantan region is different. The history of earthquakes recorded by BMKG (2019) in this area states that there have been several earthquakes in the past 5 years. For this background, an analysis of the seismicity of the Kalimantan area is carried out

This study, specifically, identifies the seismicity that occurred on the Island of Kalimantan and the period of repetition of the earthquake (recurrence period.) The results of this analysis aimed to identify areas of potential earthquake hazard.

### Regional Geology

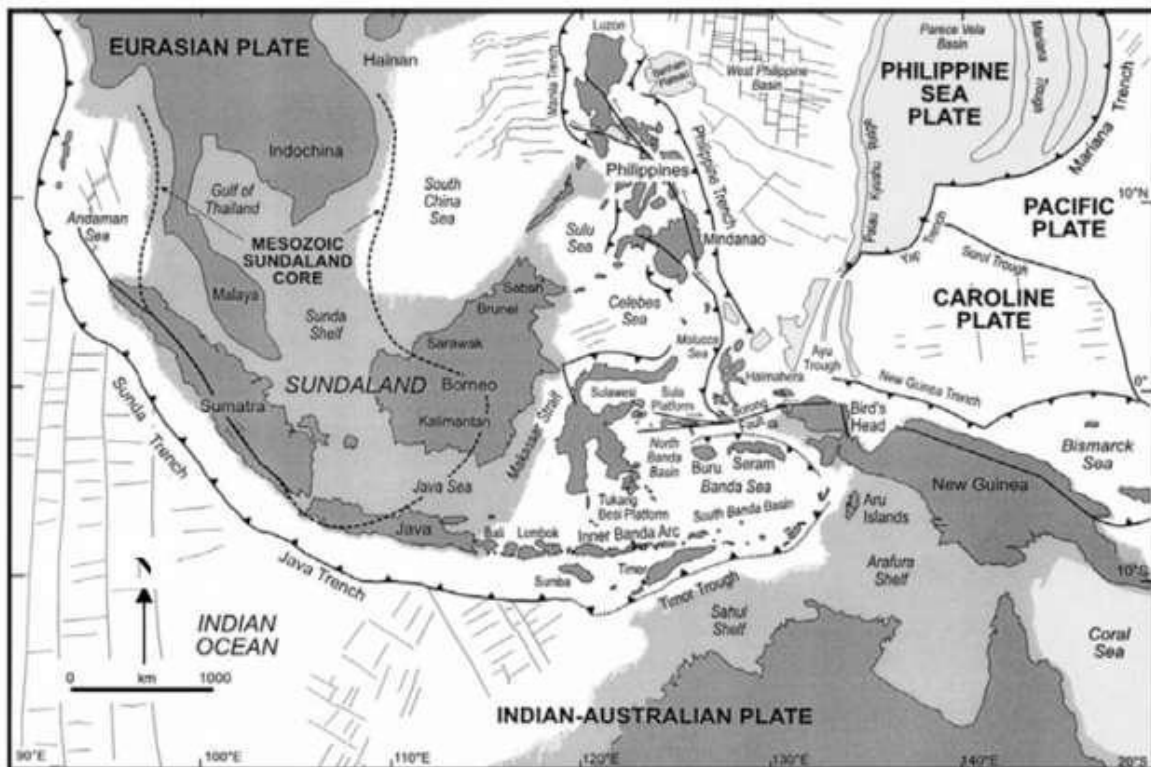
Tectonically, the Kalimantan Island is part of the Eurasian continental plate (Hall, 2002) which moves at a speed of 0.4 cm/year and collides with the Indo-Australian plate in the south. The area where these two plates assemble is called a subduction zone. The geographical location of Kalimantan Island is in the northern part and far from the subduction zone, this causes this area to be much more stable than other areas in Indonesia.

The morphology of the Island of Kalimantan is partly composed of hills to steep hills in the middle, some of it is plain to undulating plains. The coastal area is dominated by plain to wavy plain morphology. The morphology of hills to steep hills is composed of Pre-Tertiary and Tertiary rocks, while the morphology of plains to wavy plains is generally composed of Quaternary-aged deposits in the form of alluvial deposits, river deposits, swamp deposits, and coastal deposits.

Based on the stratigraphy, this area consisting of Pre-Tertiary (mélange) and Tertiary (sedimentary and volcanic rocks). Meanwhile, quarterly deposits generally dominate coastal areas, valleys, and sediments around rivers and are still unconsolidated. Some Pre-Tertiary and Tertiary rocks are thought to have undergone weathering.

### Seismicity

Kalimantan Island is the only island in Indonesia that is far from the subduction zone, causing this area to have the lowest seismicity. The seismicity in this area is most likely dominated by the activity of the major faults that cut the Island. The major faults found in this area are the Meratus Fault, Tarakan Fault, and Mangkalihat Fault with strike-slip fault mechanism. The overall length of the fault segment is above 100 Km and has the potential to produce an earthquake with a magnitude of 7.



**Figure 1.** Tectonic setting of western Indonesia (Hall, 2002)

(1) The Tarakan Fault located in the northern part of the island of Kalimantan, extending from the mainland to the open sea in the northwestern part of Sulawesi. (2) Meratus Fault is a thrust fault found in the south of Kalimantan Island. (3) The Mangkalihat Fault, which is a transform fault, is found on the east coast of Kalimantan Island and is seen joining the Palu-Koro Fault in the northwest-north of Sulawesi Island. Several previous researchers (Hamilton, 1979; Moss and Chamber, 1999; Hall and Nichols, 2002; Simons, *et al.* 2007; Hutchison, 2007), found several other faults such as the Adang Fault in West Kalimantan, the Tinjia Fault in Sarawak, the Sangkulirang Fault in East Kalimantan and the Paternoster Fault in the Makassar Strait. Some of the recorded earthquake events include those that occurred on June 5, 2015, in Ranau area with a magnitude of 6, December 21, 2015, in Tarakan area with a magnitude of 6.1, June 24, 2016, with a magnitude of 5.1, 25 February 2015 with a magnitude of 5.7 in the northeast of Tarakan and 12 July 2018 in Katingan with a magnitude of 4.2. Those above earthquakes caused losses that endangered infrastructure to take the lives of the surrounding population.

## RESEARCH METHODS

In this study, the methodology applied is to conduct a review and evaluation of seismic

activity on the Island of Kalimantan using the *likelihood* method to obtain the values of *b* and *a*.

The data used in this study is secondary data including the earthquake events sourced from the Meteorology, Climatology and Geophysics Agency (BMKG) with a magnitude  $\geq 5$  and a depth of 0 – 325 Km during 2009 – 2020, as well as geological information in determining seismotectonic on the Kalimantan area.

The level of seismicity activity can be determined by the activity parameter of value *a* which is the value of the seismicity state, and also *b* value which is the value of tectonic state. In this calculation, the likelihood method is used where the values of *a* and *b* are obtained from the following equation:

$$b = \frac{\log e}{M - M_0} \dots\dots\dots(1)$$

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$$a = \log N + \log(b \ln 10) + M_0 b \dots\dots\dots(2)$$

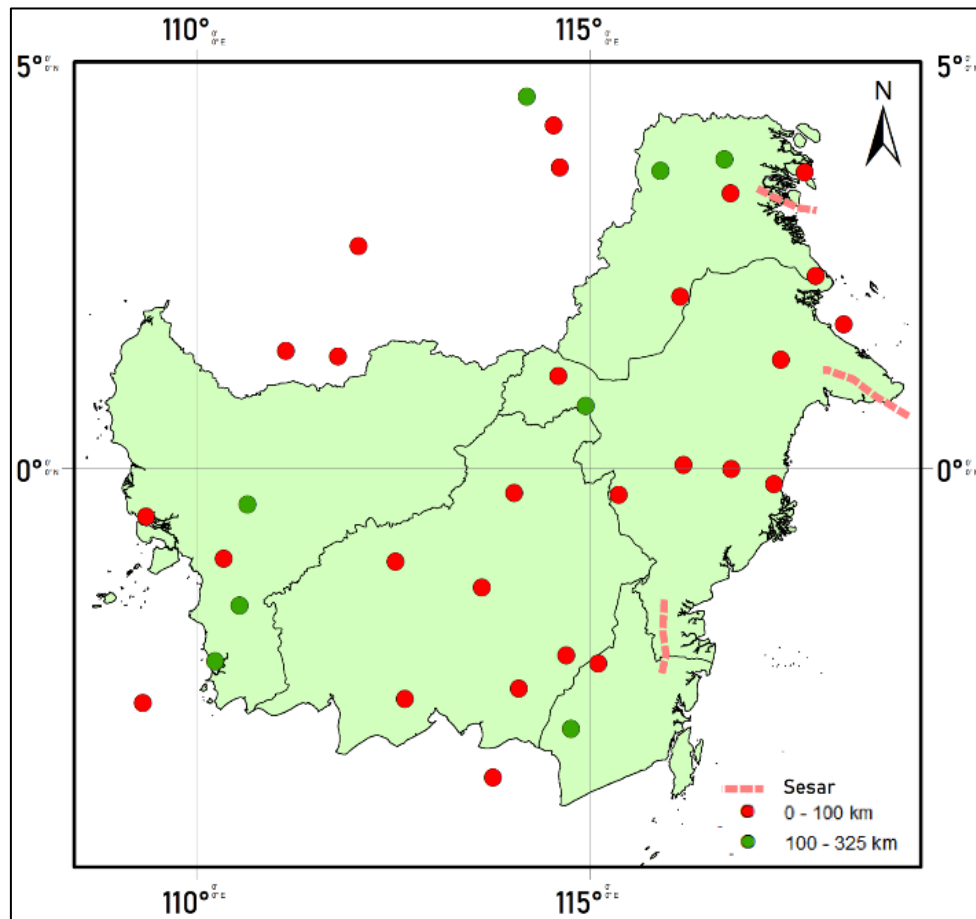
*M* is the average magnitude of the earthquake, *M<sub>0</sub>* is the minimum magnitude and *N* is the cumulative number of earthquakes with a magnitude  $\geq 5$  (Richter Scale).

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The earthquake with the highest magnitude of 6.5 with a depth of 10 km was between the Tarakan Fault and the Mangkalihat Fault. Otherwise, the deepest earthquake occurred with a depth of 325 km and a magnitude of 5.3 in the northern waters of the Kalimantan Island. As it is seen from the distribution of earthquakes in Figure 1, the distribution of shallow earthquakes is in areas adjacent to 3 major faults on this Island.

The seismicity level of the Island of Kalimantan is known by using the parameters of the seismicity state value (a) and the tectonic state value (b) where the seismicity level that triggers the earthquake is linked to the high value of a and b.

From the sorted data, the calculation of the b value is calculated using the *likelihood* method.



**Figure 4.** Earthquake event distribution (2009-2020) data source: [http://repogempa.bmkg.go.id/repo\\_new/](http://repogempa.bmkg.go.id/repo_new/).

The calculation results show the value of a is 2.71222 and value b is 0.64077. This explains seismic activity on the island of Kalimantan is lower compared to several large islands in Indonesia.

However, this area must remain vigilant, such as the 2015 earthquake in the north of the Tarakan fault with a magnitude of 6,0 with the potential for a tsunami (BMKG, 2015).

## CONCLUSION

Based on the analysis results of the earthquake data from 2009 – 2020 with a magnitude  $\geq 5$  in the Kalimantan Island region using the likelihood method, it can be concluded that the

seismicity of Kalimantan obtained value of a is 2.71222 and value of b is 0.64077. This value shows that the area of Kalimantan Island has a low level of earthquake activity. However, some areas close to the major fault zone in Kalimantan still need to be watched out for because there is a chance for a large earthquake to occur in the area.

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