



Originally published as:

Muksin, U., Irwandi, Rusydy, I., Muzli, Erbas, K., Marwan, Asrillah, Muzakir, Ismail, N. (2018): Investigation of Aceh Segment and Seulimeum Fault by using seismological data; A preliminary result. - *Journal of Physics: Conference Series*, 1011.

DOI: <http://doi.org/10.1088/1742-6596/1011/1/012031>

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To cite this article: U. Muksin *et al* 2018 *J. Phys.: Conf. Ser.* **1011** 012031

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Investigation of Aceh Segment and Seulimeum Fault by using seismological data; A preliminary result

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Abstract. The Seulimeum Fault has not generated large earthquake after last large earthquake with magnitude of M 7.3 occurred in 1936. The Seulimeum Fault is accompanied by the Seulawah volcano that reported to be active in 1839, 1975 and 2010. The activity of the Seulimeum Fault could be related with the existence of the Seulawah volcano and the Seulawah volcano activity could also triggered by the Seulimeum Fault activity. The objective of the longterm research is to investigate the relation between the Seulimeum Fault and the Seulawah Volcano. The aim of this paper is to present the first result of the investigation of the Seulimeum Fault based on the seismicity and geomorphology. A seismic network consisting of 17 seismometers (Trilium Compact) and data logger (DSS Cube) were deployed in Aceh Besar. The seismic network was installed for 3 months to record earthquakes along the Seulimeum and the Aceh Faults. The Seulimeum Fault is considered to be active as several local earthquakes were recorded. The Seulimeum Fault is much more active in the region of the bifurcation of the The Aceh Segment and the Seulimeum Fault. The mechanisms of earthquakes along the Seulimeum Fault were mostly strike slip following similar to the Sumatran Fault characteristics.

1. Introduction

Aceh is one of the very seismically active region in the world that has generated more than 2200 earthquakes with magnitude larger than M 6.0 since 1990 to November 2004. The Aceh region has become much more active after the Mw 9.3 2004 Aceh earthquakes indicated by more earthquakes with magnitudes larger than M 6.0 occurred[1]. The sources of large earthquakes could be from the subduction zone, the Wharton Ridge, the Sumatran Fault and even from the secondary faults. Although the magnitudes of inland earthquakes in Aceh were smaller than those along the subduction zone, inland large earthquakes with magnitude between M 6.0 and M 7.0 could be much more destructive than those along the subduction zone since the inland earthquakes are located close to the population. Among secondary faults in Aceh that has generated destructive earthquakes included the Lampahan Fault in Central Aceh on July 2nd, 2013 and in Pidie Jaya on December 6th, 2016. One of the secondary faults that has not released large earthquake is the Seulimeum Fault which is located in the northernmost Aceh (Figure 1).



The Seulimeum Fault is one of the secondary faults in Sumatra that could generate destructive earthquake with magnitude larger than M 7.0 as a large earthquake occurred along the fault in 1936 [2]. Although there is no report of large earthquake along the Seulimeum Fault, the Seulimeum Fault has been generating small scale earthquakes [3]. Small scale earthquakes often generated along secondary faults that close to volcanoes e.g. in Tarutung[4] and in Central Aceh[5]. The Seulimeum Fault is accompanied by the Seulawah Volcano which was reported to be active in 1975, 2010, and 2013 indicated by tremor earthquakes.

The seismic activities along the Seulimeum Fault could be related to the Seulawah Volcano and also the Seulawah Volcano activity could be caused by the seismic activities along the Seulimeum Fault. Therefore the objective of the research is to investigate the characteristics of the Seulimeum Fault from the seismic activities and its relation to the Seulawah Volcano. The seismicity distribution along the Seulimeum Fault could delineate the Seulimeum Fault complemented by geomorphology.

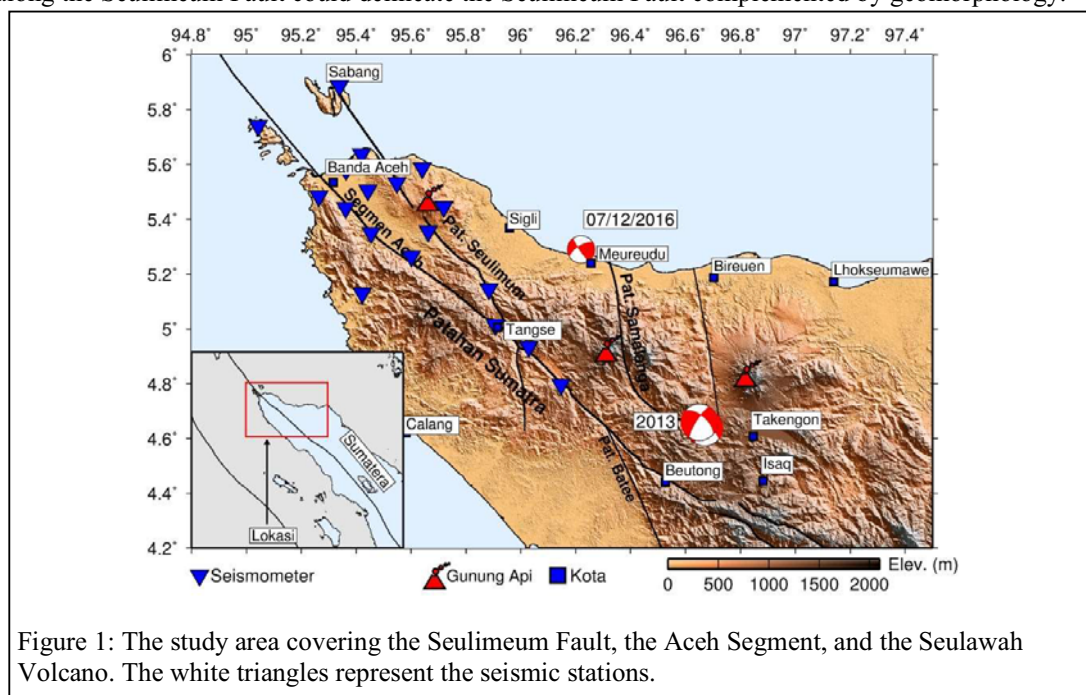


Figure 1: The study area covering the Seulimeum Fault, the Aceh Segment, and the Seulawah Volcano. The white triangles represent the seismic stations.

2. Data and Methods

A seismic network consisting 17 seismometers and DSS Cube data logger provided by GFZ-Potsdam was installed in Aceh Besar, the northernmost Sumatra. We used broadband seismometers and recorded the waveforms in the DSS Cube datalogger with the sampling rate of 100 sps. The seismic network covered the main geological features including Seulawah Volcano, The Seulimeum Fault, and the Aceh Segment in the region of 4.8 N- 5.6 N and 95.4 E – 96.0 E as shown in Figure 1. The network was deployed for three months because of the limitation of the instrument availability since January 2017. This kind of seismometer distribution in general could detect earthquakes with magnitude down to M 2.0 depending on the noise level around the seismometers.

The seismic waveforms from all the stations were downloaded manually and the P and S arrivals were observed visually (picked manually). The first preliminary locations of the earthquakes were determined by using HYPO71 [6]. The earthquakes were then relocated by using a simultaneous earthquake relocation and 1D velocity determination [7]. Several 1D velocity models were employed then the inversion is conducted for each velocity model. The RMS values of each result are compared

and the velocity model with the smallest velocity model is chosen as the best 1D model. The 1D velocity model could then be used for seismic imaging to study the structure of the beneath the area of interest including the Seulawah Volcano.

3. Preliminary Results and Discussion

The northernmost region of Aceh is relatively seismically active indicated by several earthquakes recorded along the Seulimeum Fault and the Aceh Segment. Figure 2 shows the waveforms of an earthquake along the Seulimeum Fault in the Krueng Raya region. The waveforms indicate that even within 40 seconds (Figure 2) two earthquakes occurred along the Fault.

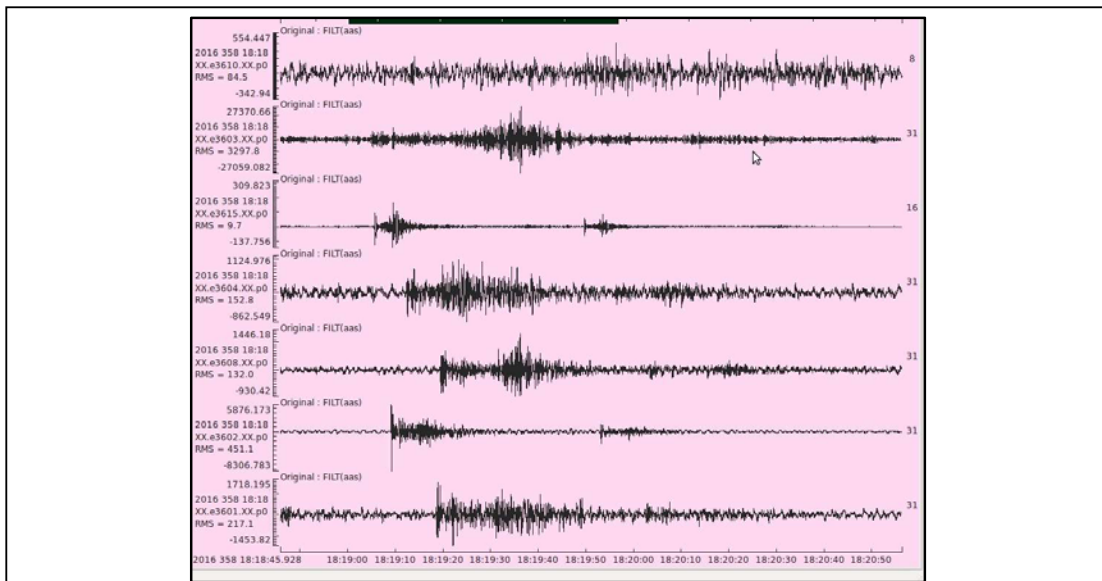


Figure 2: An example of recorded seismic waveforms of an earthquake that occurred in Krueng Raya, Aceh Besar

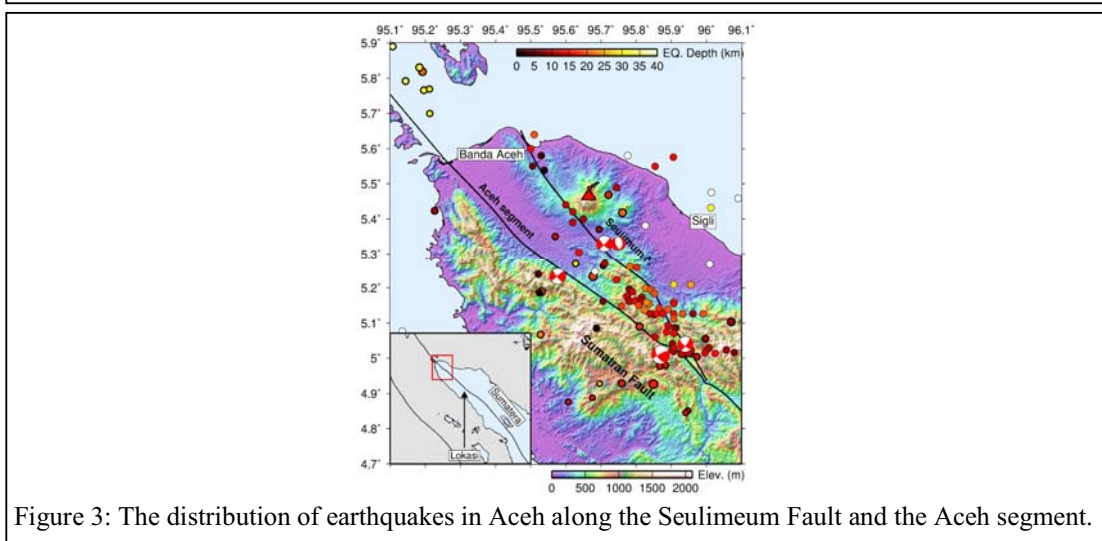


Figure 3: The distribution of earthquakes in Aceh along the Seulimeum Fault and the Aceh segment.

The distribution of earthquakes is shown in Figure 3 indicating that both, the Seulimeum and the Aceh Faults are currently active. Both faults are much more active in the region close to the bifurcation the two faults. The Seulimeum Fault is also active in the Krueng Raya region. The historical earthquake also indicated that the Kreung Raya region was active. A large earthquake occurred around Krueng Raya that affected the region significantly. The local earthquake data has not been fully analyzed but we could suggest the pattern of the fault from the focal mechanisms provided by International Seismological Center[1]. The focal mechanisms of the earthquakes indicate that the Seulimeum Fault is right lateral strike slip which is almost similar to the Sumatran Fault. The Seulimeum Fault strikes NNW-SSE while the Sumatran Fault similar to the fault line we derived from the earth elevation model (ASTER-GDEM).

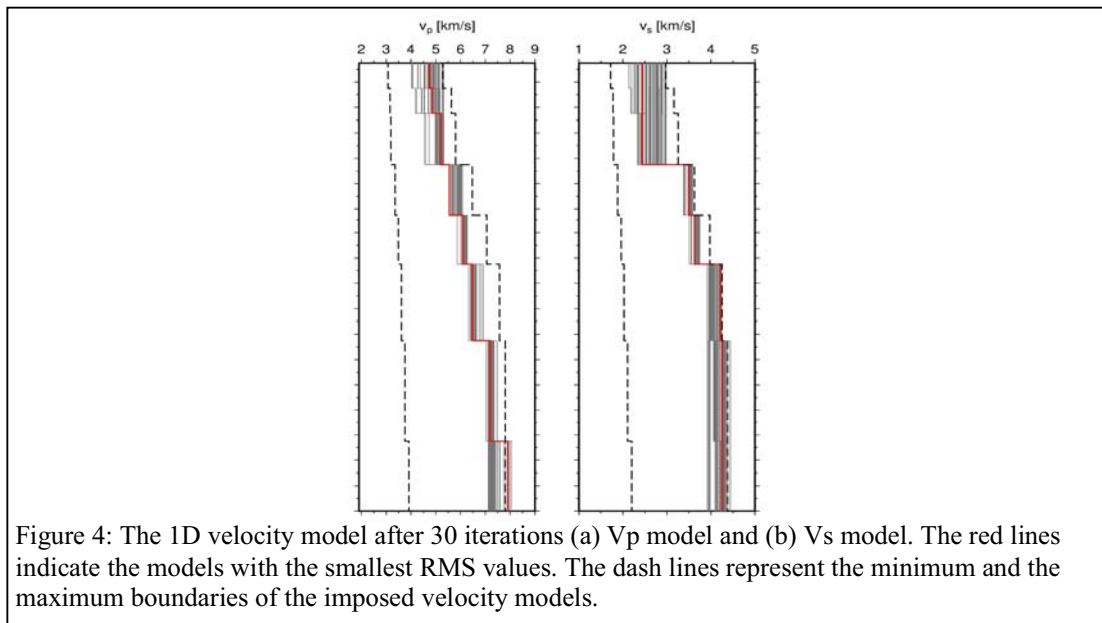


Figure 4: The 1D velocity model after 30 iterations (a) V_p model and (b) V_s model. The red lines indicate the models with the smallest RMS values. The dash lines represent the minimum and the maximum boundaries of the imposed velocity models.

The locations of the earthquakes need to be relocated by using a simultaneous earthquake relocation and velocity determination. We have experimented to obtain the 1D velocity model as shown in Figure 4. We imposed 64 initial velocity models and then the 1D inversion was applied for each initial model with 30 iterations. The initial models were chosen arbitrarily to be within the boundary corridor indicated by dashed line in Figure 4. All imposed models converged to one best velocity model indicated by red lines in Figure 4. The 1D velocity model will be used for imaging the structure beneath the study area.

4. Conclusion

The Seulimeum Fault and the Aceh segment seem to be active as several local earthquakes recorded along the faults. Both segments are more active in the region close to the bifurcation of the two faults. The Seulimeum Fault is also active in the Krueng Raya region. We have determined the 1D velocity model of the northernmost Sumatra (Aceh Besar) that could be used for further analysis to image the seismic structure of the Seulawah Volcano and the structure beneath the faults. The Seulimeum Fault is right lateral strike-slip similar to that of the Sumatran Fault.

5. References

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Acknowledgments

The research is funded by the Indonesian Government under the scheme of Penelitian Unggulan Universitas 2017-2019. The seismic instruments were provided by Research Center for Geosciences, GFZ-Potsdam. All maps were created by using generic mapping tools (GMT-PLOT).