

# Relocation and Focal Mechanism of Aftershocks Pidie Jaya Earthquake (Mw6.5) Dec 7<sup>th</sup>, 2016 using BMKG Network

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**Abstract:** We have successfully relocated 74 out of 89 aftershocks until December 19, 2016, by using hypocenter double-difference method. We also have conducted focal mechanism analysis to estimate the type of fault slip. The results indicate improvement in hypocenter location, where the initial earthquakes focus depth at a fixed depth of 10 km have been updated and have described the patterns of active fault in the area trending Northwest-Southeast. The validity through the histogram of travel-time residual shows fairly good data processing where the residual value is close to zero ( $t_{obs} - t_{cal} = 0$ ). Based on focal mechanism solutions of mainshock and two aftershocks, the type of fault is right lateral strike-slip.  
**Keywords:** Relocation, Focal Mechanism, Fault

## 1. INTRODUCTION

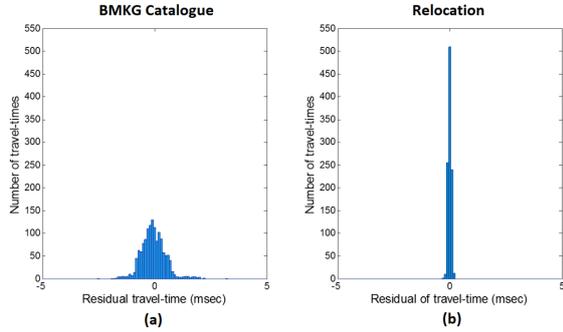
On December 7th, 2016 an earthquake occurred in Pidie Jaya, Aceh, Indonesia. According to Indonesian Agency for Meteorological, Climatological and Geophysics (BMKG), this earthquake occurred at 05:03:36 a.m with a magnitude Mw 6.5, the epicenter is located at 5.29° N, 96.22° E with a depth of 15 km. The authority has been reported at least 102 fatalities and 700 people were injured and thousands of buildings were damaged. About a minute after the mainshock, followed by sequences aftershocks until a few weeks later.

## 2. DATA AND METHOD

The data used in this study from the arrival-time of the BMKG earthquake catalog on 7 to 19 December 2016. During this period there were 89 aftershocks with magnitude 2.9 to 5.0 at depths of

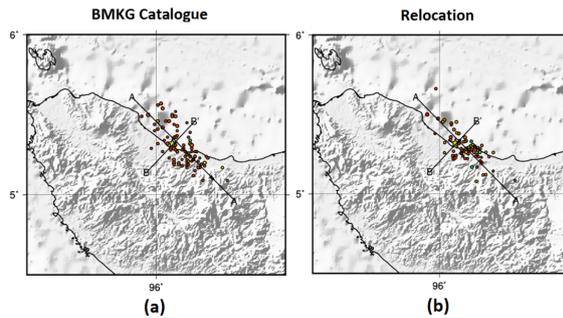
10 to 33 km with 922 of arrival-time P-phase and 381 of arrival time S-phase. The velocity model of IASPEI91 was used for the hypocenter determination in BMKG catalogue (Kennett and Engdahl, 1991) by using SeisComp3 Program (GFZ). Travel-time residual of BMKG catalogue is shown in Figure 1a. In addition, we used the waveform of mainshock and selected aftershocks from the BMKG seismic station network in North Sumatra and surrounding areas.

We used HypoDD program (Waldhauser, 2001) to running the Double-Difference method (Waldhauser and Ellsworth, 2000), for the relocation of the hypocenter. The method assumption that if there are two earthquakes by the distance hypocenter is smaller than the distance of the hypocenter of the station, then ray path of earthquakes are considered equally and propagating passed medium the same also. Start from searching catalog P- and S-phase data for event pairs with travel time information



**Fig. 1.** Residual of travel-time (msec) (a) BMKG catalogue, (b) after relocation using Double-Difference method.

at common stations and subsamples these data in order to optimize the quality of the phase pairs and the connectivity between the events. HypoDD minimizes residuals between observed and calculated travel time differences in an iterative procedure and, after each iteration, updates the locations and partial derivatives, and re-weights the a priori weights of the data according to the misfit during inversion and the offset between the events. The method has been successfully applied for the updating earthquake hypocenter location in Sumatra (Ramdhan and Nugraha, 2012), western part of Java (Sakti et al., 2012), Palu-Koro fault (Ismullah et al., 2017), Banda arc (Utama et al., 2015) and Papua region (Sabtaji and Nugraha, 2015).



**Fig. 2.** Distribution of the aftershocks Pidie Jaya earthquake (a) BMKG Catalogue, (b) After relocation using Double-difference method. Red to green circle is the epicenter of the earthquake based on depth in km.

For performing moment tensor inversion, we used ISOLA package (Sokos and Zahradnik, 2008). We inverted for full moment tensors from the displacement records from at least three local stations. Waveform on the stations that has the closest distance to the epicenter were chosen in data processing, considering the magnitude of the

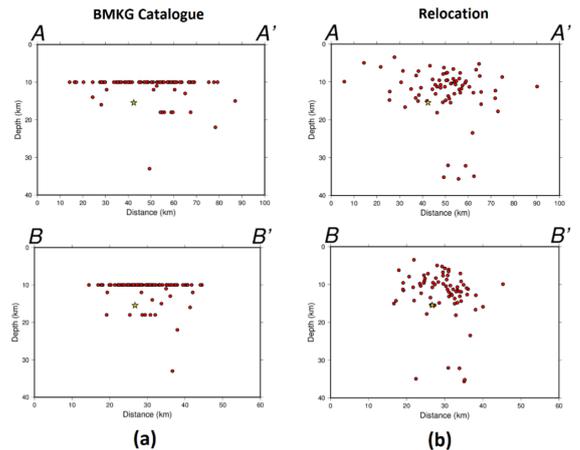
aftershocks is quite small, so if the distance between the hypocenter and the station is relatively far away, then the waveform is not clear. The observed waveforms were pre-processed by highpass filtering with a corner frequency of 0.015 Hz to 0.065 Hz. Comparison of the correlation coefficient between the observed and the best fitting synthetic seismograms is more important for the success of the inversion. Starting conversion data from SAC to ASCII format, input of earthquake parameter (origin time, latitude, longitude, and depth), input of velocity model and selected stations, removing the instrument response, trial seismic source, and Green function calculation. We used 1-D seismic velocity model from AK135 (Kennett, 2005). We plotted all figures by using General Mapping Tool (Wessel and Smith, 1998).

### 3. RESULT AND DISCUSSION

We validated the results of relocation from histogram of residual travel-time (Figure 1) shows good data processing, where the residual value after relocation is close to zero ( $t_{obs} - t_{cal} = 0$ ).

We have successfully relocated 74 of 89 aftershocks Pidie Jaya earthquake, then we compare the relocation result with the data before the relocation (Figure 2).

Based on Figure 2, updated of hypocenter location in the horizontal direction after relocation shows a clearer pattern trending Northwest-Southeast.



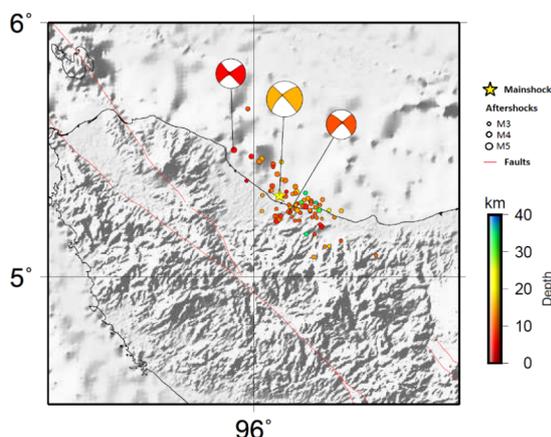
**Fig. 3.** Cross-section of the aftershocks Pidie Jaya earthquake (a) BMKG Catalogue, (b) After relocation using Double-difference method.

To shows the updated of the hypocenter location in the vertical direction we make a vertical cross-section in parallel and perpendicular of the alignment

**Table I .** Parameters of focal mechanism solution for mainshock and aftershocks

	Mainshock		Aftershock 1		Aftershock 2	
	NP1	NP2	NP1	NP2	NP1	NP2
Strike	318	226	140	231	316	225
Dip	86	70	86	85	78	86
Rake	-160	-5	175	4	-176	-12

pattern. We can see that the hypocenter before the relocation a lot the earthquake with fix depth in 10 km, then the depth changes after the relocation.



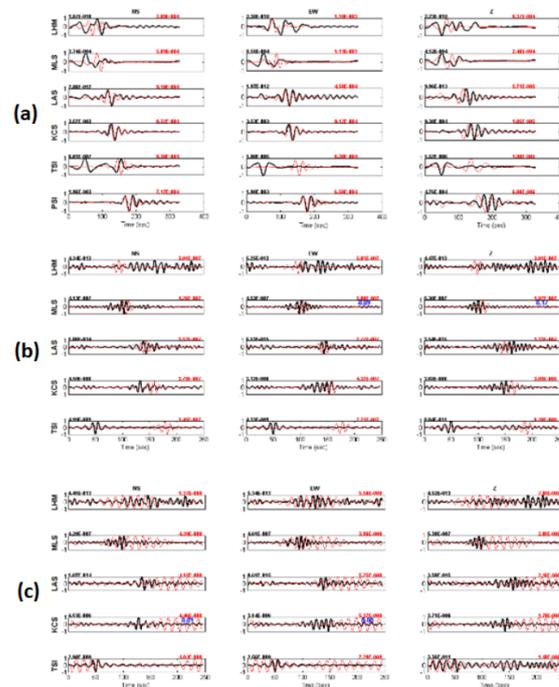
**Fig. 4.** Focal mechanism of mainshock and selected aftershocks.

Based on focal mechanism solution of mainshock and two aftershocks events (the parameters showed in Table 1) indicate the type of fault is a lateral strike-slip. Where the straightness is trending northwest-southeast, so the type of fault is a right lateral strike-slip.

Waveform fitting (Figure 5) between the observed and the synthetic seismograms showed the good data processing.

#### 4. CONCLUSION

Hypocenter relocation of aftershocks Pidie Jaya earthquake indicate improvement in hypocenter location, where the initial earthquakes focus depth at a fixed depth of 10 km have been updated and have described the patterns of active fault in the area trending Northwest-Southeast. Based on focal mechanism solutions of mainshock and two



**Fig. 5.** Waveform fitting for (a) mainshock, (b) and (c) aftershocks. Red waveform is syntetic and black waveform observation.

aftershocks, the type of fault is right lateral strike-slip.

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