Identification Fault Characteristic in Southern Sulawesi by Focal Mechanism

by Muhammad Massinai

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Abstract. Sulawesi has complex tectonic, signed by fault like Palu-Koro Fault, Walennae Fault, Matano Fault, Batui Fault and others. Mostly fault located on Southern Sulawesi and it caused earthquake in Southern Sulawesi. The aim at this study is to learn fault characteristic by focal mechanisms in Southern Sulawesi. Focal mechanism is method to analyze movement mechanism based on first polarity of earthquake P-wave to determine fault caused by earthquake fault which caused earthquake. In this study is located on Southern Sulawesi with 2°26' - 6°50' S and 118° -123°50' E during 1976 – 2016 from Global-CMT. The hypocenter plotted to identify location of the earthquake. The fault parameter, such as strike, dip and slip plotted to interpret focal mechanism of fault caused earthquake. The data plotted by GMT to get distribution focal mechanism on Southern Sulawesi which shown 46 beach-balls. For interpretation, it divided into 3 regions; region I show oblique-reverse fault related to Makassar Thrust. Region II show left-strike-slip fault related to Matano Fault activity. Region I shows Paternoster fault and earthquake by sea spreading at Bone Gulf; Walennae Fault with strike-slip fault activity. Region III the most complex region show normal fault related to Tolo Fault activity. Region III shows Kolaka fault with strike-slip fault activity and earthquake by interaction between micro-continent observed as oblique-reverse fault activity.. The focal mechanism in this study effectively to observe the fault activity which can be used as guided for earthquake mitigation.

1. Introduction

One of high seismicity area in Indonesia is Sulawesi especially in Southern Sulawesi. This is resulted by complex tectonic as shown in Fig. 1 (red square) in around Sulawesi Island. The activities gave manifestation of tectonic which affecting earthquake disaster area. The manifestation of these tectonic setting formed of faults and volcanoes. The faults in Sulawesi Island such as Palu-Koro fault, Walennae fault, Matano fault, Batui fault and others [1] which mostly located on Southern Sulawesi.

Area of earthquake energy release will cause earthquake called earthquake focus. Source of earthquake come from fault motion, so earthquake focus do not represent a point, but an area unfolding some kilometres. From focus, earthquake spread out seismic wave. Among all that P-wave is the easiest to be analysed, because P-wave is the first wave arrive.

P-wave signal which recorded by seismograph, can give information of compression or dilatation from the fault. So if the seismograph mapped at nodal plane, the data will represent a beach ball called Schmidt Diagram, which drawing focal mechanism. Focal mechanism is method to analyze movement mechanism of fault which caused earthquake [2]. The result parameters are strike, dip and slip of the

fault. With these parameters, every point focused can be analyzed as strike-slip fault, reverse fault or normal fault. The aim at this study is to determine fault characteristic by focal mechanism in Southern Sulawesi.

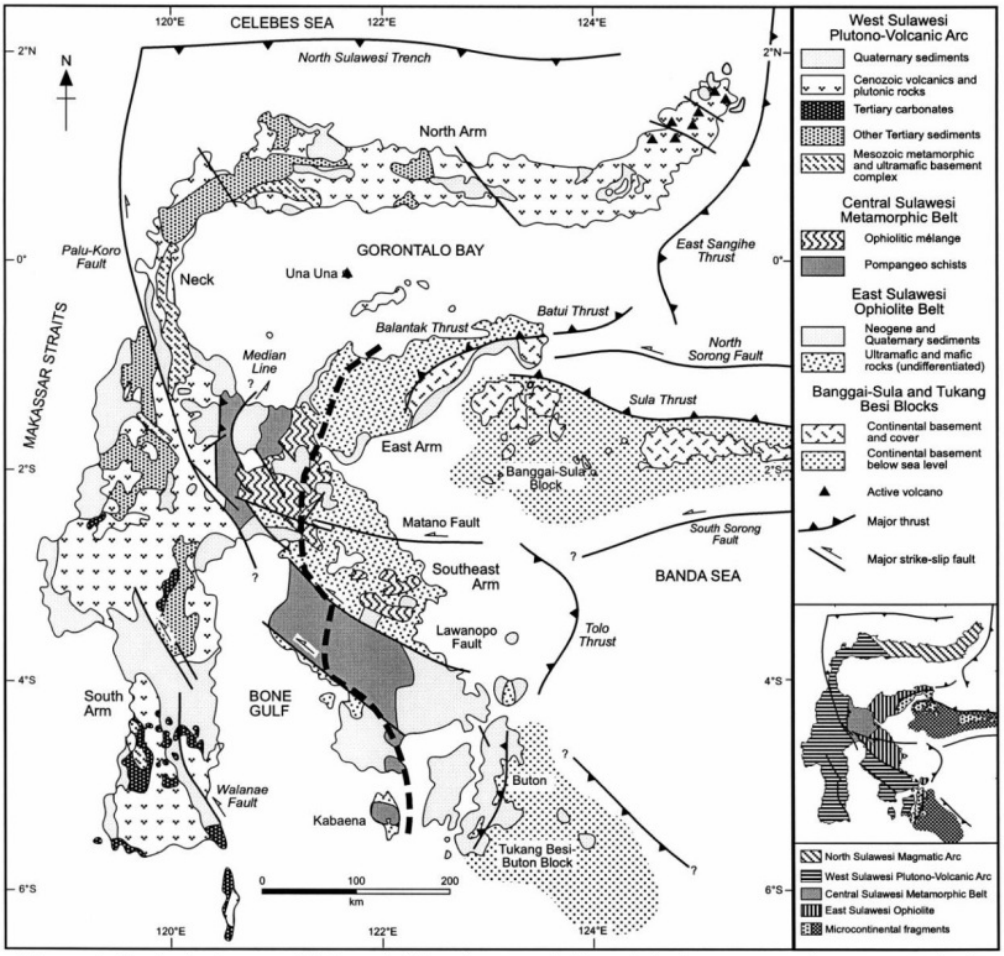

Figure 1. Geological map of Sulawesi [5], red square indicated the interest area due to many faults existing.

2. Data and Methods

The research object located on Southern Sulawesi and some small island around it. The research object limited by 2º26' - 6º50' S and 118º -123º50' E. The used data is the secondary data of earthquake data from 1976 – 2016 from Global-CMT [3]. The data included information about hypocenter, magnitude, origin time of earthquake and fault parameter: strike, dip and slip.

Data processing is started from making the earthquake distribution map based on hypocenter and magnitude. This research used earthquake data with magnitude > 4. The hypocenter plotted to identify location of the earthquake. The fault parameter, such as strike, dip and slip plotted to interpret focal mechanism of fault (Fig. 2) caused earthquake. The data plotted by GMT [4] to get distribution focal mechanism in Southern Sulawesi.

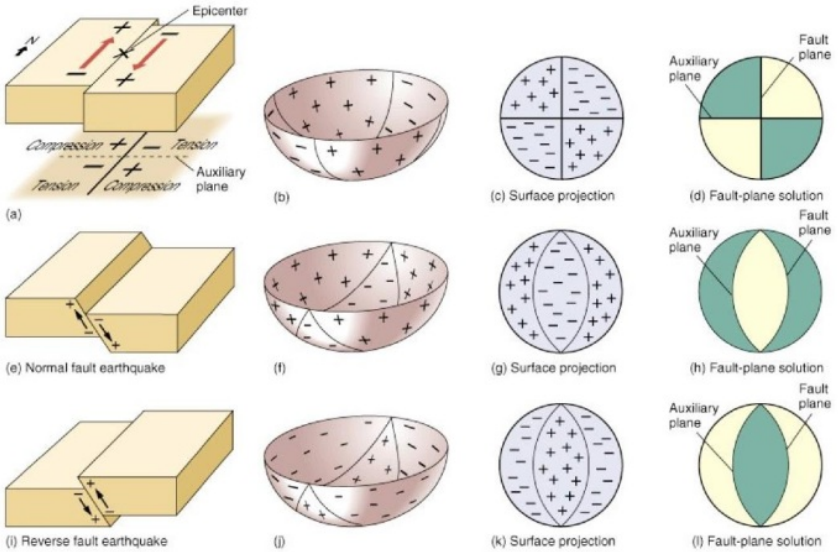

Figure 2. Relation between movement mechanism of fault and their focal mechanism [6].

3. Results and Discussion

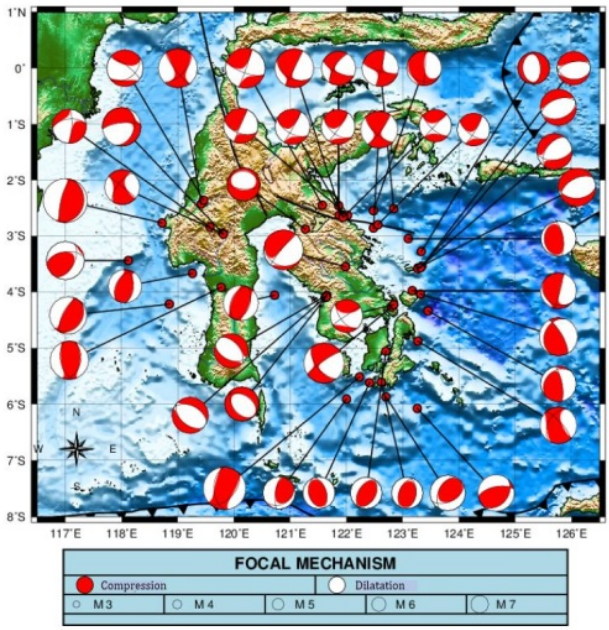

Figure 3. Distribution of focal mechanism in Southern Sulawesi.

According to Fig. 3, showed 46 beach-balls. For interpretation, it divided into 3 regions: Region I (green rectangle), II (blue rectangle), III (white rectangle).

Region I

In region I (Fig. 4), earthquake dominated caused by thrust fault in sea. This related to Makassar Thrust and Paternoster Fault activity. Makassar Thrust located on northern Makassar Strait through Central Sulawesi and Paternoster Fault located on southern Makassar Strait [7]. Overall, two fault on Makassar Strait signed by oblique-reverse fault activity on focal mechanism. So, it can say Makassar Thrust and Paternoster Fault are oblique-reverse fault. Reverse fault activity showed on Bone Gulf. It caused sea spreading occurred on this location.

In land, there are strike-slip fault activity. It may be related to Walennae Fault. The epicentre located at Walennae depression, which located between West Walennae Fault and East Walennae Fault as part of Walennae Fault. West Walennae Fault is a sinistral strike-slip fault and East Walennae Fault as a reverse fault with a dextral component of slip [8]. So, this focal mechanism may shows West Walennae Fault activity.

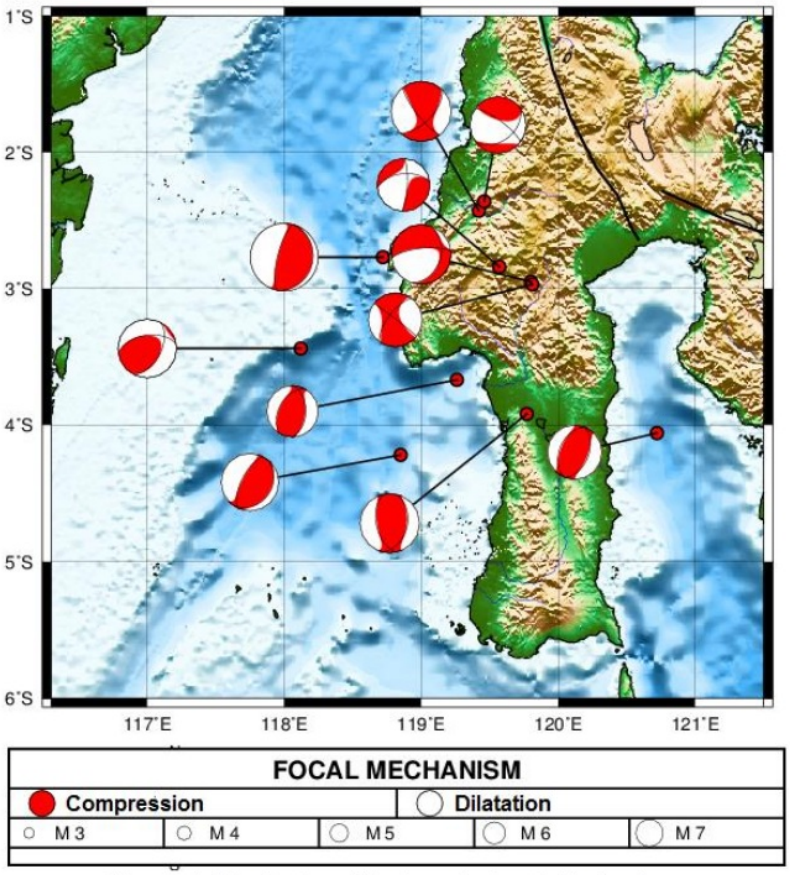

Figure 4. Distribution of focal mechanism in Region I.

Region II

Fault pattern of region II (Fig. 5) dominated by left-strike-slip fault. Hypocentre located on Matano Fault area. So, the left-strike-slip fault related to Matano Fault activity. But, there is other tectonic regime which showed reverse fault. This earthquake affected from Sula Fault at eastern Matano Fault [1]. This result similar with GPS and earthquake slip vector data [9].

Matano Fault is an active fault which is northwest – southeast direction. This fault have contributed on formation of Matano and Towuti Lake [10].

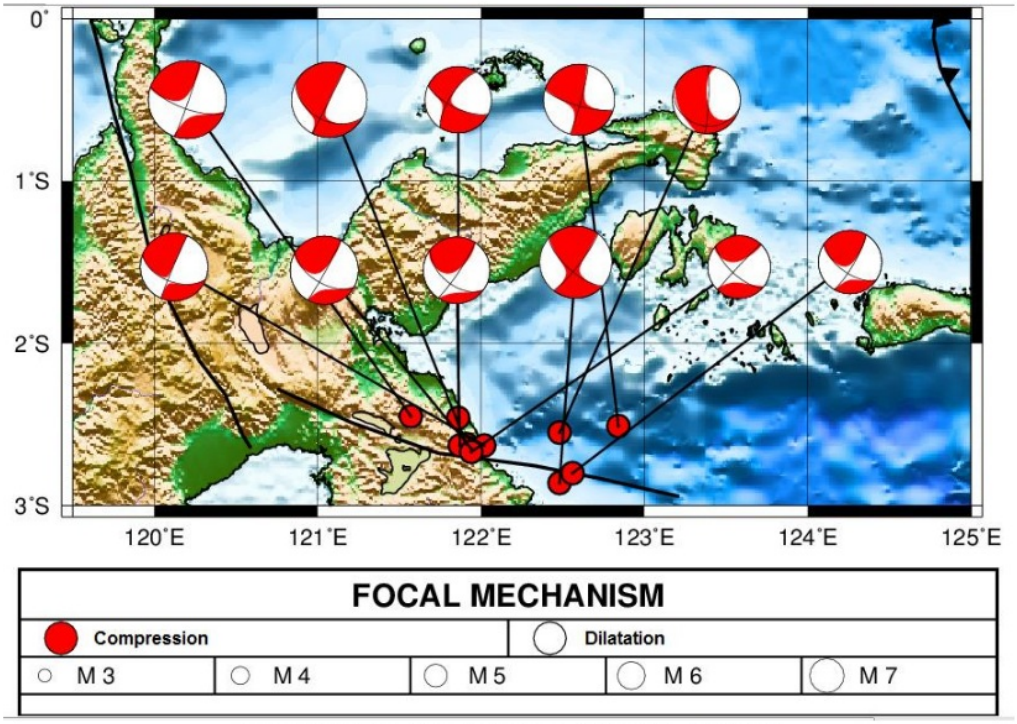

Figure 5. Distribution of focal mechanism in Region II.

Region III

Region III has more complex than other. Tolo Fault activity showed in this location. Normal fault could become the main factor caused the earthquake in the sea. But the focal mechanism also showed oblique and reverse fault (Fig. 6 left). Tolo Fault, also known as Tolo Thrust, is reverse fault [11, 12]. Oblique and normal fault mechanism on thrust showed active thrusting which is oblique mechanism occurred on 200 – 450 km and normal mechanism deeper than 450 km [13]. Tolo Thrust is the subduction to the west of the North Banda Sea [12].

In land, there are normal fault and left-strike-slip fault (Fig. 6 right). This related to Kolaka Fault activity. Kolaka Fault has northwest – southeast direction and left-strike-slip fault activity [11]. But, there is normal fault activity, it may be related to minor fault of Kolaka Fault, is Lambatu Fault [10]. It can say that Kolaka Fault is left-strike-slip fault.

Oblique and reverse fault maybe affected by movement of micro-continent. This movement could observe on southern Southeast Arm of Sulawesi (Fig. 7). Mostly focal mechanism showed oblique-reverse fault. This represent microcontinental fragments derived from Australia that collided with the accretionary terrain of eastern Sulawesi during the Miocene [14].

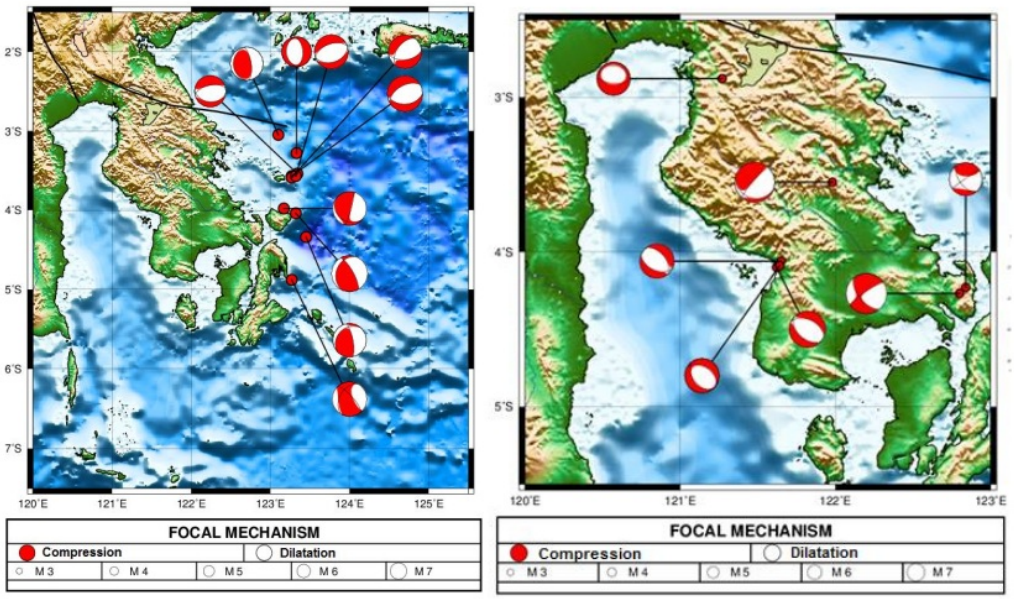

Figure 6. Distribution of focal mechanism of Tolo Fault (left) and in land (right), in Region III.

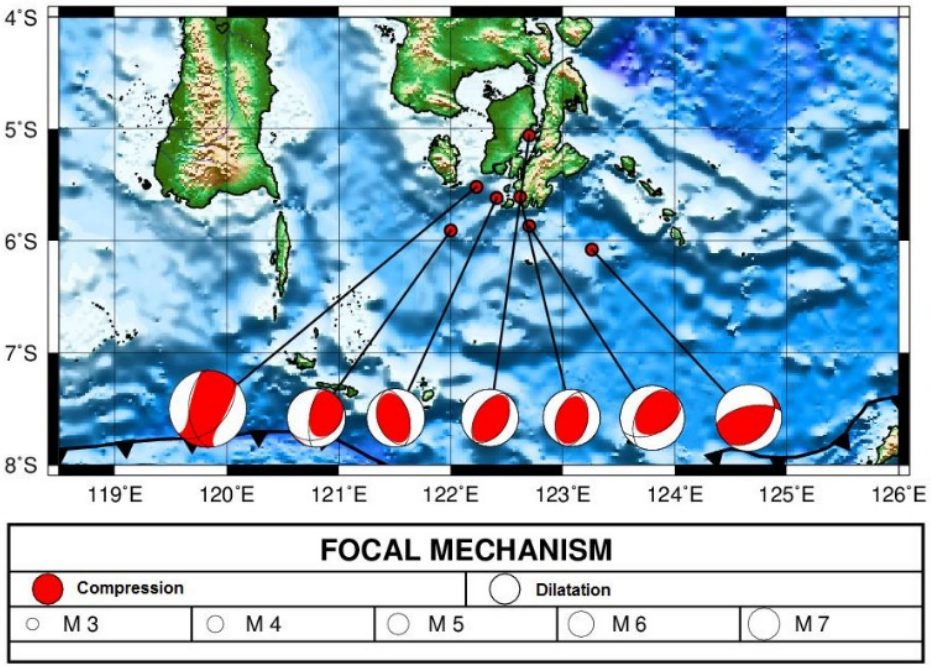

Figure 7. Distribution of focal mechanism of microcontinent, in Region III.

4. Conclusions

Based on previous section, it can conclude that focal mechanism can observe the fault activity. Such as Makassar Thrust and Paternoster Fault (oblique-reverse fault), Walennae Fault, Kolaka Fault and

Matano Fault (strike-slip fault) and Tolo Fault (reverse fault). Further, focal mechanism can analyse micro-continent movement in Southeast Arm of Sulawesi. This research can more informative if completed by other data, like geology, tectonic, geodesy etc.

In the next step, the study will continue for determining tectonic stress in Southern Sulawesi. And, this result can help government and citizen to prepare earthquake mitigation in this location.

Acknowledgements
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