Geomagnetic Data Interpretation Using 2D Modeling of Subsurface Rock Layer Structures in the Palu Valley Province, Central Sulawesi

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Abstract. Interpretation of the subsurface rock layer structure model has been carried out using geomagnetic data in the Palu Valley. Geomagnetic data is obtained through field measurements using the Proton Precision Magnetometer. Modeling is done using total magnetic field intensity data. The research objective is to determine the geological structure and subsurface rock layers. The modeling results show that at the study site, there are four rock layers and several faults mapped in the western, central, and eastern parts of the study location. Based on the susceptibility value, the rock structure at the study site consists of granite and sedimentary rocks, but the types of sedimentary rocks are different. The layer on the surface consists of alluvium according to what is exposed in the field. The second layer is thought to be sandstone which extends in harmony with the rock above it from west to east. The third layer is in the form of sandy clay which extends from the central part to the east and is not aligned with the layer above it while the lowest layer consists of granite rocks that are faulted in the western and eastern parts of the study area.

Keywords: Fault · Susceptibility · Rock Layer

1 Introduction

Palu Valley is an area that is functioned by several people as a place to live and carry out various activities, both sociocultural, economic, and government activities. Palu City is one of the areas located in the Palu Valley which is crossed by the Palu Koro fault so this area is very prone to earthquake hazards. This fault is thought to have caused a damaging earthquake event whose center is located around the Palu Valley and is thought to be related [1]. This fault is thought to have caused a damaging earthquake event whose center is located around the Palu Valley and is thought to be related. The earthquake that occurred on September 28, 2018, centered about 100 km north of Palu City, generated waves that propagated in all directions and caused rock deformation so that it was possible for local fractures and faults to occur. Some local fractures and faults that form are exposed on the surface so that they can be observed directly, but the formation of cracks or faults does not only occur on the surface but also occurs below the

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surface [2]. Information on the geological structure and subsurface rock layers is very important, especially in the development and planning of infrastructure development. This information is needed to carry out mitigation so that disaster risk can be reduced. Therefore, it is necessary to map subsurface local fractures and faults which can be used as a reference in making sustainable development plans.

One of the technologies that can map the subsurface is geophysical technology, especially the geomagnetic method. This method has been widely used by various researchers in mapping the subsurface, for example, modeling hot water reservoirs in the Bora geothermal field, Central Sulawesi [3]. Application of the magnetic method to describe the fault in the eastern part of Cairo, Egypt [3]. Applying magnetic data to describe the lineament structure at Sinai Peninsula, Egypt [4]. Specifically in the study area also by Efendi *et al.* has carried out geomagnetic measurements where the results are in the form of interpretation using Euler's deconvolution [5]. The results obtained identified geological structures in the form of contacts and faults at the study site with depths varying from 0 to 2000 m. The geological structures in the form of contacts and faults detected at the study site spread from east to west in a generally north-south direction corresponding to the Palu–Koro fault. In this study, 2D modeling was carried out using geomagnetic data that had been measured and processed [5]. The aim is to describe a 2D model of the subsurface geology structure in the study area using geomagnetic data.

2 Geological Settings

The research location is located in the Palu Valley, first introduced by Sarasin and Sarasin in 1901 as the sarasina fossa which stated that the Palu Valley was formed as a result of a graben. The results of research conducted by Sudrajat have identified various geological phenomena [6], for example such as former old river flows, old talus, superposition between alluvium fans and several fault escarpments buried by fan deposits [7]. The Palu Koro Fault is a place of displacement between parts of the Pacific plate and the Asian plate. The area of Palu City and its surroundings is an alluvial plain that extends in a relatively north-south direction and is bounded by slopes and ridges on both sides of the valley [8]. This plain is dominated by Holocene alluvial lithology units consisting of silt, loam, sand, gravel and gravel. At the bottom there are rocks from the Lariang Formation which have been occupied by Granite Complexes and Diorite Complexes as well as metamorphic rocks from the Latimojong Formation [9]. The distribution of the geological conditions of the Palu valley and its surroundings can be seen on the geological map as shown in Fig. 1.

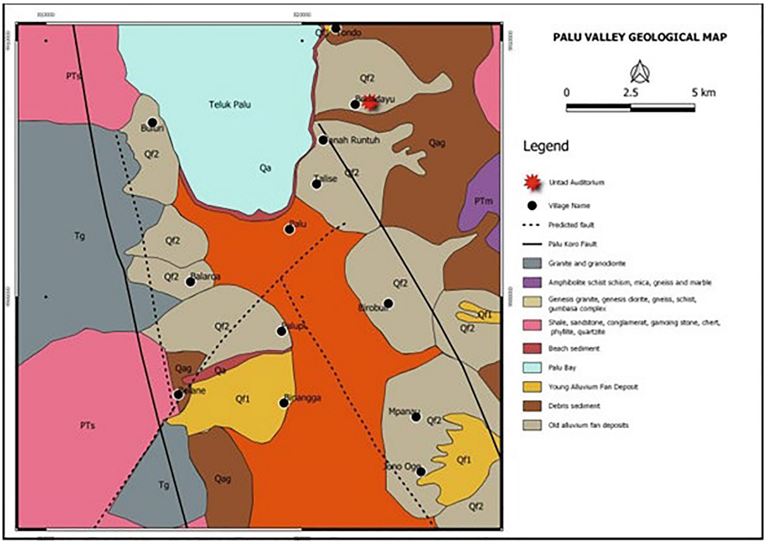

Fig. 1. Geological map of the research site. This map redrawn from [7]

3 Magnetic Data

Magnetic data obtained from measurements that have been carried out by Efendi *et al.* using a 10 T proton precession magnetometer [5]. The result of the corrections made to magnetic data is total magnetic intensity. The distribution of magnetic data measuring points and the distribution of total magnetic intensity was mapped using the Oasis Montaj software from Geosoft as shown in Fig. 2a and Fig. 2b. It appears that the distribution of magnetic intensity values ranges from −55 nT to 45 nT. Magnetic intensity values vary greatly from relatively low to high. This is caused by the existence of different types and layers of subsurface rocks. The relatively low magnetic intensity is in the west-south direction and the high magnetic intensity is relatively in the south-southeast direction. Based on the distribution of magnetic intensity, this low anomaly is thought to be due to rocks consisting of alluvium and sandstone, with a high intensity caused by igneous rocks in the form of granite.

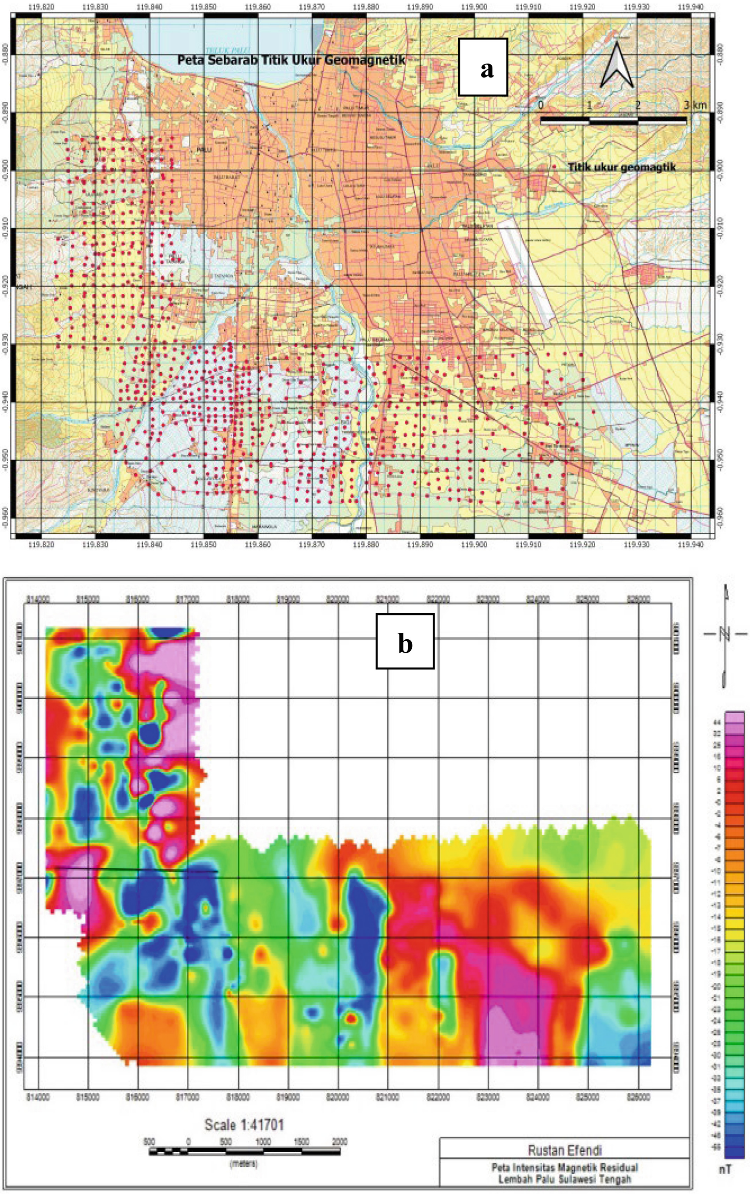

Fig. 2. (a) Map of the distribution of geomagnetic measuring points (red circles) overlaid with the Earth's map of the Palu valley of Indonesia. (b) Map of the total magnetic field intensity overlaid with the model trajectory (black line) by [5]

4 Result and Discussion

In this study, modeling was carried out using GM-SYS 2D software from Geosoft. The model is built based on magnetic data to describe the geological structure and subsurface rock layers. Furthermore, to obtain a subsurface description of the research location, 2-dimensional (2D) modeling was carried out on 1 track located to the west. The selection of the trajectory location was made with the consideration that the fracture zone and the Palu-Koro fault plane are located west of the Palu Valley. The track length is about 3200 m with the east-west track direction as shown in Fig. 2. The modeling was carried out according to the match between the response of the magnetic data model and the measurement data response with an error presentation of less than 2% as shown in Fig. 3A. The build model is based on the geological conditions of the study area data. The modeling results show that the distribution of susceptibility values (k) of subsurface rocks is around 0.00001 SI to 0.00825 SI. Susceptibility values spread linearly downwards while laterally they are not aligned. Low susceptibility rocks are located around the surface while high susceptibility values are located at depth. Furthermore, to obtain a model of geological structure and subsurface rock layers, interpretation is carried out based on the value of the distribution of rock susceptibility. The results of the interpretation of rock types based on the susceptibility value can be seen in the Table 1.

Figure 3 in part A is the response to the magnetic intensity of the built model shown by the black dotted line while the black lines show the response to the magnetic field intensity resulting from the correction of data measured in the field. The difference between the total magnetic field intensity response of the model and the total magnetic intensity response resulting from field data correction indicates that the error rate of the model built is less than 2%.

The 2D modeling results show compatibility with the geological conditions of the study area as described by Soehami *et al.* [8] which consists of 4 layers of rock with a geological structure in the form of local faults and fracture zones as shown in Fig. 3B. Faults and fracture zones may be caused by seismic waves generated from earthquakes on September 28 2018. The rock layer structure is composed from the surface downwards consisting of continuous alluvium (yellow) from the barracks to the east with varying thicknesses. The second layer is sandstone (green) extending from west to east and is cut in certain parts by faults. The third layer is sandy clay (green-black) which is located in the middle to the east but is cut by faults and the fourth layer is the deepest rock consisting of granite (pink) rocks. The geological structure in the form of a fault

Table 1. Interpretation of rock types based on the distribution of susceptibility values of subsurface rocks

Layer	Susceptibility (SI)	Rocks type
1	0.00002	Alluvium
2	0.00001	Sandstone
3	0.000025	Sand clay
4	0.00455–0.00825	Granite

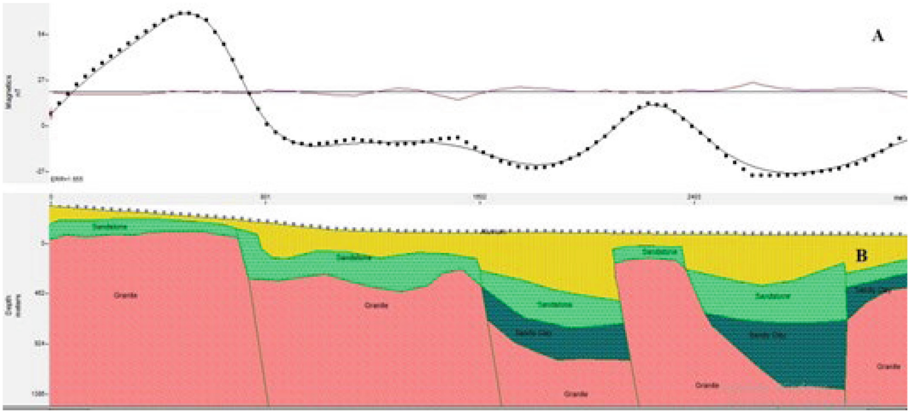

Fig. 3. (A) total field intensity response resulting from field measurement data correction (discontinuous black dots) and model response (continuous black line) and (B) Model of geological structure and subsurface rock layers.

appears in the western, central and eastern parts of the track which are embedded and covered by a layer of alluvium. The subsurface geological structure model obtained is in accordance with the results of the fault plane exposed on the surface by Abdullah *et al.* [10], especially the fault area on the west side.

5 Conclusion

Based on the results of modeling the subsurface geological structure of the study area, several things can be concluded as follows:

The geological structure model shows that the bedrock conditions are relatively complex, consisting of faults with 4 layers of rock that are arranged in a non-conformist manner. This is thought to be caused by the activity of the Palu Koro fault. The rock layer structure model based on depth consists of layers of alluvium on the surface, sandstone, sandy clay, and granite respectively.

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