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Interpretation of Subsurface Geological Structure of Massepe Geothermal Area Using Resistivity Data

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ABSTRACT

Massepe geothermal area is located in Sidenreng Rappang Regency, South Sulawesi Province, Indonesia, approximately 194 km north of Makassar.

The geology of the area consists of Miocene marine sedimentary rock, Tertiary volcanic rock and Quaternary of lava domes that are interpreted as the heat sources of the geothermal systems of the area. The geothermal features include hot springs, volcanic gas bubbling and hydrothermal altered rock.

The morphology is high relief terrain composed of Tertiary volcanic rock that occupies the west side, and flat area composed of Tertiary marine sedimentary rock at the east side, where some geothermal surface manifestations occur.

Resistivity data show indications of geological structures on the sedimentary basin such as lava domes, rock bedding and normal faults. These fault structures are interpreted to control geothermal surface manifestation of the area.

1. INTRODUCTION

Lateral and vertical changes of lithology and its composition close to the surface produce various resistivity values, that can be detected and used in order to improve information on a given geological surface area. The aim of this work is to estimate the changes of resistivity from the west to eastern side and show indications of geological structures on the geothermal prospect area.

Massepe geothermal area is located at 119^o 44' 15,5 to 119^o 51' 17,25 longitude and -3^o 56' 41 to -4^o 4' 30,6 latitude (Figure 1.a). It is situated on a plain morphology which is a depression zone in consequence of northwest – southeast Wallanae normal fault movement, where the northeast block moves relatively downward over another one. As geothermal features, two 41–68ºC hot springs, Pajalele and Alakuang, appear on this depression zone.

In consequence of downward relative movement on the eastern side, the morphology is characterized by a steeply sloping hill on the west side, afterwards a smooth sloped hill which is composed of volcanics with andesitic composition. Continuing to the northeast, the morphology tends to be plain morphology up to Sidenreng lake, where recent surface deposit, alluvium is being formed. Andesitic to dacitic composition lava domes are predicted as heat source related product of Massepe geothermal system (Figure 1.b).

Measurements of resistivity data, based on Schlumberger configuration, have been carried out with AB/2 250, 500, 800, and 1000 meters for mapping and 1.6 to 2000 meters for VES. The number of measurement points is 69 for mapping and 24 for VES that were distributed on 8 lines at intervals of 500 meter

2. GEOLOGY AND GEOTHERMAL FEATURES

At the eastern side, the oldest rock is observed as sedimentary rock which is part of the Tertiary Wallanae Formation. Tertiary volcanic rocks lay at the western section of the investigation area, afterwards, younger volcanic (Pliocene) material is situated on the southwestern side where Quarternary sediment consists of lake deposit, unconformably overlaid on the east - northeastern section (Figure 2).

The youngest igneous rock is interpreted as lava domes which intrude through older rock formation. These units have andesitic to dacitic composition and are interpreted as heat source related intrusive bodies beneath the surface. Fission track dating method shows that the lava dome unit is 1.8 ± 0.2 million years old, thus is interpreted as the latest volcanic activity in this area (PMG survey geologi, Yuanno, Dikdik, Fredy).

The developing geological structures in Massepe are mostly normal faults, whether NW-SE striking (Wallanae fault and Kalampee fault), NE-SW striking (Bulu Baka fault), or N-S striking (Alakuang fault and Massepe fault). Massepe fault situated in the central part is identified by the appearance of hot springs, Pajalele hot springs (58.8 - 68.0^{o}C) and Alakuang hot spring (45.3^{o}C), moreover, identified by deformation zone around the hot springs which is observed as brecciation of limestone. This fault is interpreted as the controlling fault for the appearance of Pajalele and Massepe hot springs.

3. INTERPRETATION OF RESISTIVITY DATA

A map of apparent resitivity for AB/2=250 to 1000 meter is shown in Figure 3 , and from VES data, we obtain a cross section of true resistivity for every line in Figure 4.

Low resistivity value (10 – 20 Ωm) is shown from the eastern part and is enhanced gradually to the west. Based on review of the geology, it is interpreted as a half-graben structure which is forming Sidenreng lake and extensional structure inside (Figure 4). This pattern is shown continously to AB/2 800m, and possibly continues at AB/2 1000m. Therefore it is clearly possible that the central part to eastern part of the investigation area is a depression zone, filled by surface deposit sediment which has low resistivity value (Figure 3).

An isolated contour of low resistivity value (<10 Ωm) is shown around Pajalele hot spring on AB/2 250m to 1000m which differentiate the sedimentary pattern as mentioned above. The continuity of this pattern has given an assumption that it occured over a structural intersection. The structural intersection of Massepe fault and the half-graben fault seems to control this geothermal fluid flow which can be seen on Figure 3.

Another tempting result is some isolated high resistivity contour in the north-center part. It confirms geological data as lava domes which intrude through older rock formation (Figure 3). As mentioned before it is heat source related intrusive bodies and has an important role in the Massepe geothermal system.

CONCLUSION

Resistivity method can be used to define the prospect boundary in a geothermal system. Moreover, combining the apparent resistivity map and the vertical section of true resistivity allows us to infer the existence of intrusive bodies, and also subsurface structural development within the areas which have been interpreted by surface geological measurements and observations. In this work, we investigated three factors that can help in obtaining a more realistic picture: (a) coupling between apparent resistivity map and true resistivity section, (b) a geological model, with structural interpretation and (c) LandSat images or aerial photographs.

The details of the structural model of Massepe area using resistivity method such as srike-slip relative motion and its distance are still being investigated. What is more important to note is that the regional strain pattern defined by this method is helping to unravel the regional tectonic picture, and the orientation of geothermal structures.

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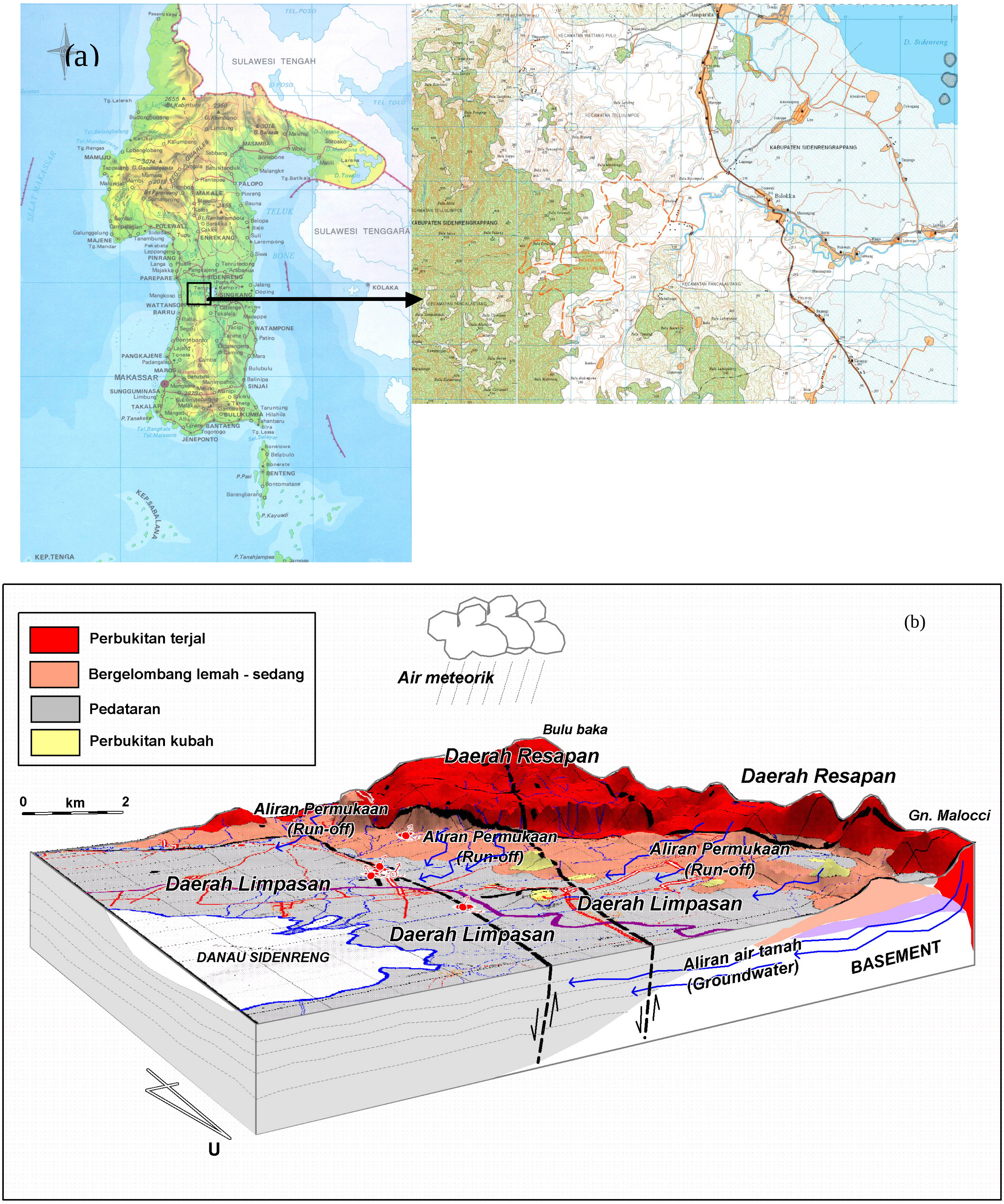

Figure 1: area Investigation at Massepe, Sidenreng Rappang,South Sulawesi Indonesia (a) and morphology map (b)

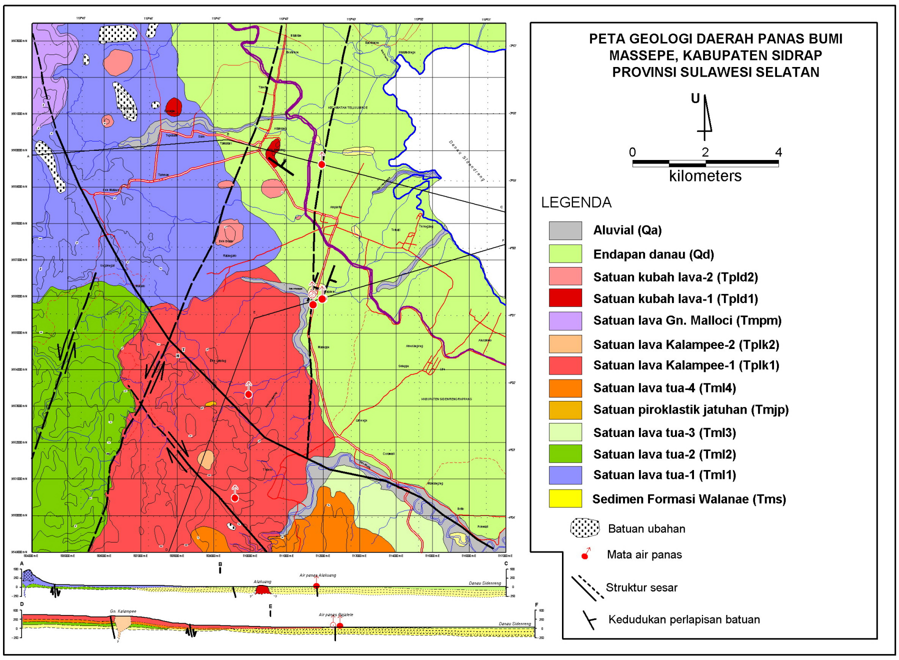

Figure 2: Geological Map of Massepe

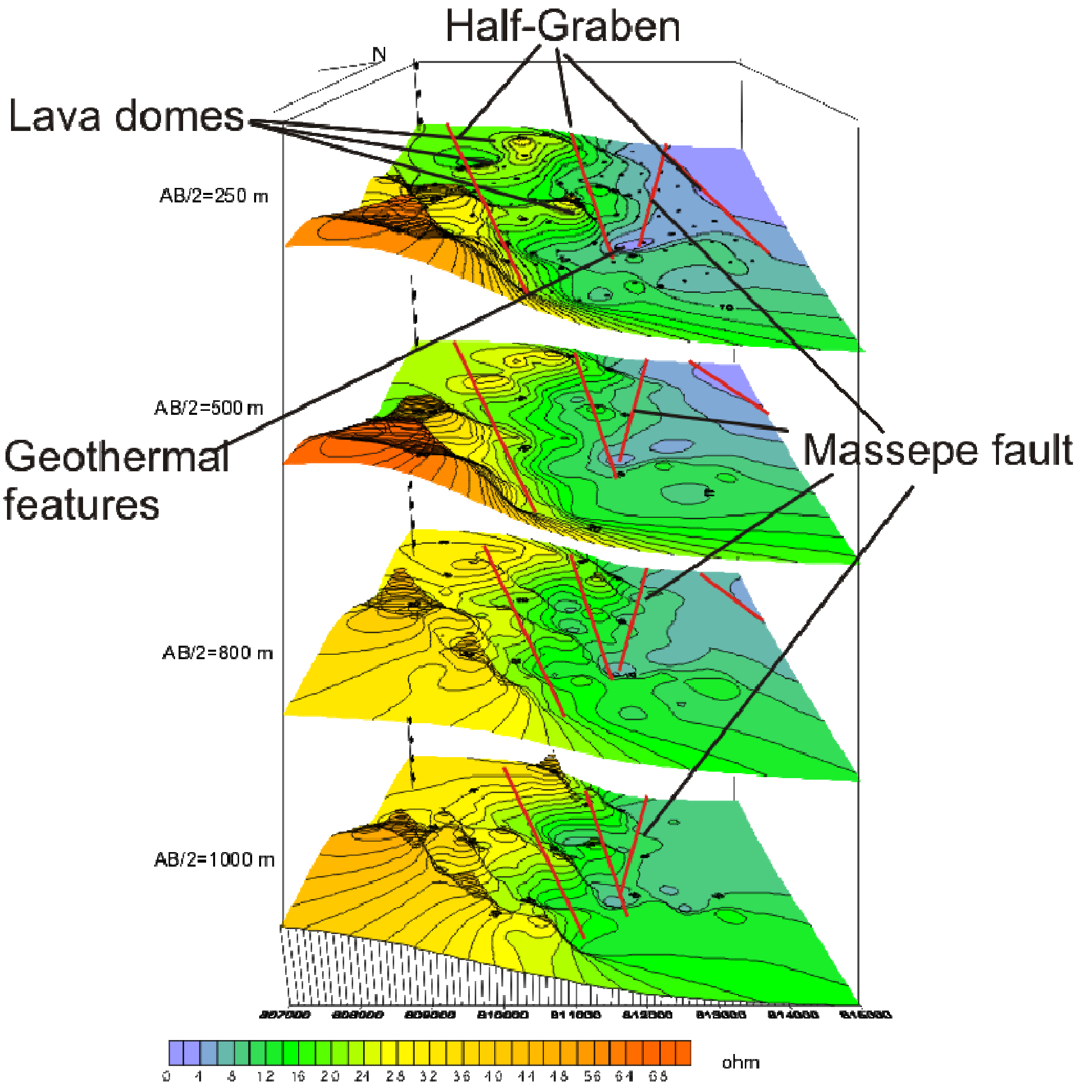

Figure 3: Interpretation of Apparent Resistivity Map

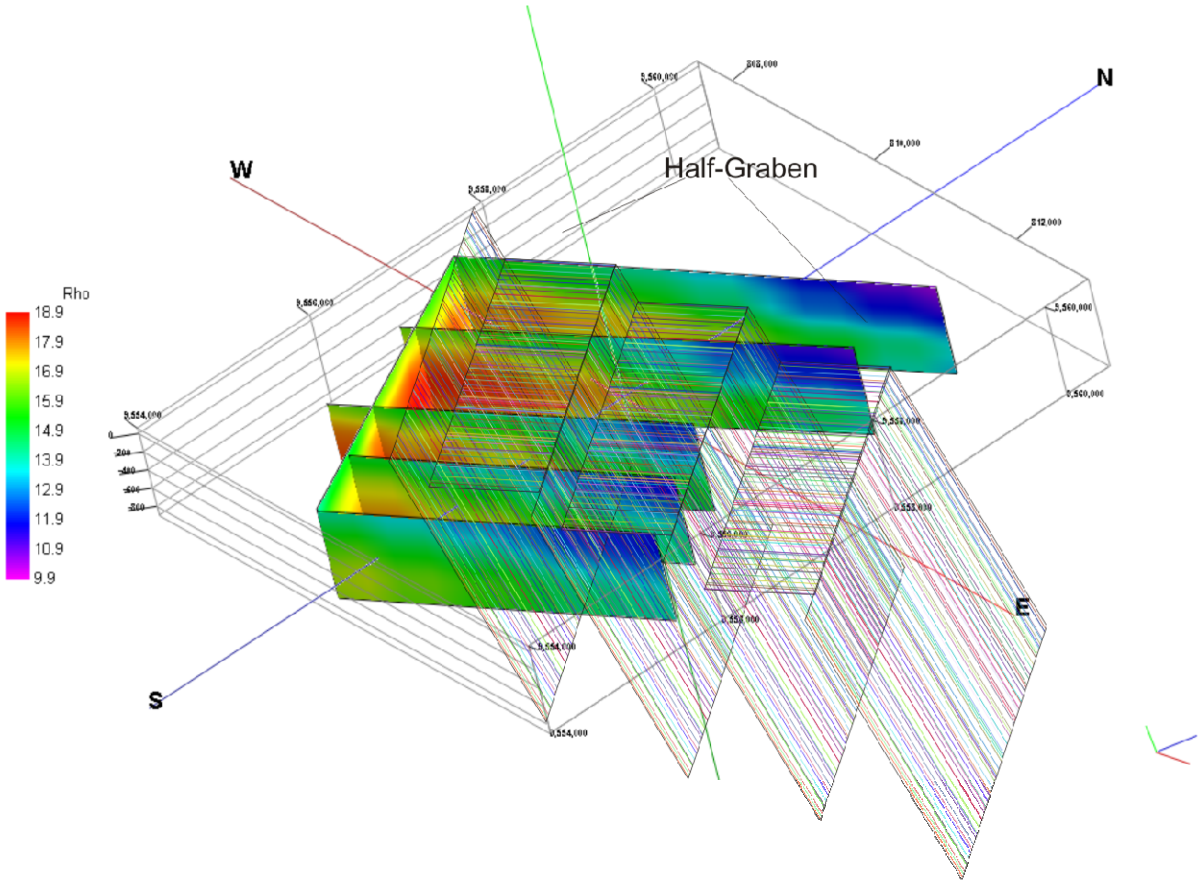

Figure 4: Interpretation of True Resistivity Section