ISSN: 978-602-71169-7-9



# Magnetic Modeling of the Diwak-Derekan Geothermal Area with Extension to Bawen, Central Java

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**Abstract.** In an effort to further advance understanding of Diwak-Derekan geothermal system, a second period of geomagnetic survey of the area including Kaliulo hot spring, Jatikurung hot spring and Kendalisodo geothermal hot spring has been carried out. The magnetic residual anomalies have been reproduced especially on the southern part of the study area. 3D magnetic analysis and interpretation of geological data acquired and collected in the field. Based on magnetic field anomaly and the field geological data, a speculation shows that magnetization intensity assumed for the existence of a cooling magma intrusion is suggested at the southern part of the study area, that is located at Sajen Village.

**Keywords:** Magnetic modelling, Magnetic anomaly, Diwak-Derekan Hot spring

## Introduction

One of the most familiar method to observe geothermal research is structure characterization on geothermal field. Magnetic method survey is one of the methods of geophysics that observe total magnetic value. The distinct magnetic total force anomalies represent many kinds of hydrothermal system, such as reservoir, alteration and geological structure [1]. Reference [2] observed low enthalpy geothermal reservoir by VES sounding giving the groundwater zone by the fault structure.

The total magnetic value will be processed by some correction and then modelled by forward modelling or inversion modelling and will get the susceptibility value. The susceptibility value will represent the lithology of rocks. Alteration of rocks due to hydrothermal fluids, will has low susceptibility. In this research we present an inversion modelling of magnetic data which has been applied. We can get value of susceptibility after input the some parameters and will get 3-Dimension of model.

Diwak and Derekan are hot springs that to be geothermal manifestation field and located the southern part of Semarang City. Previous shallow ground temperature studied shows that temperature anomalies were 30.77 $^0$C and 30.64 $^0$C with a high $CO_2$ value at around of Diwak that is 9.7% that has been interpreted that there was a permeability zone surrounding Diwak hot spring [3]. Magnetic methods has been applied and identified there were two faults with cross lineament from southwest to northeast and vice versa. The faults being transport media of hydrothermal fluids of the hot spring geothermal system [4]. Gravity method has conclusion that there was normal fault in the Diwak hotspring manifestation and there are faults that has lineament from southwest to northeast [5]. In the southeast part from Diwak and Derekan, we got intrusion rock and manifestation of Jatikurung hotspring.

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(Fitria, 2015) Forward modelling data shows that the depth of 326 to 1200 meters as a *caprock* of the Diwak and Derekan geothermal system and there is normal fault that to be transport of manifestation Jatikurung hotspring. Audiomagnetelluric method has been applied at Diwak-Derekan field supported the final conclusion that there is a heat source of the Diwak and Derekan geothermal system in the 1200 meters of depth that indicated by increasing of resistivity value. The increasing of resistivity value that indicating there are gases of the heat source (Yuanita, 2014).

## Regional Geology of Study Area

Diwak and Derekan Geothermal hot springs are located in the surrounding area occupies the geomorphological folds hills unit and hills of the complex morphology of volcanic sediment as well as some parts of the sediment which is stuffing the area between the mountain basin and mountain range complex folds as shown in Figure 1. At the appearance in field several locations , namely in Ungaran toll lanes - Bawen reveals the presence of several former escarpment and ground movement which is one expression of the morpho-tectonic morphology Resen as an indication and is a manifestation of an old fault reactivity (Poedjoprajitno, at al., 2008).

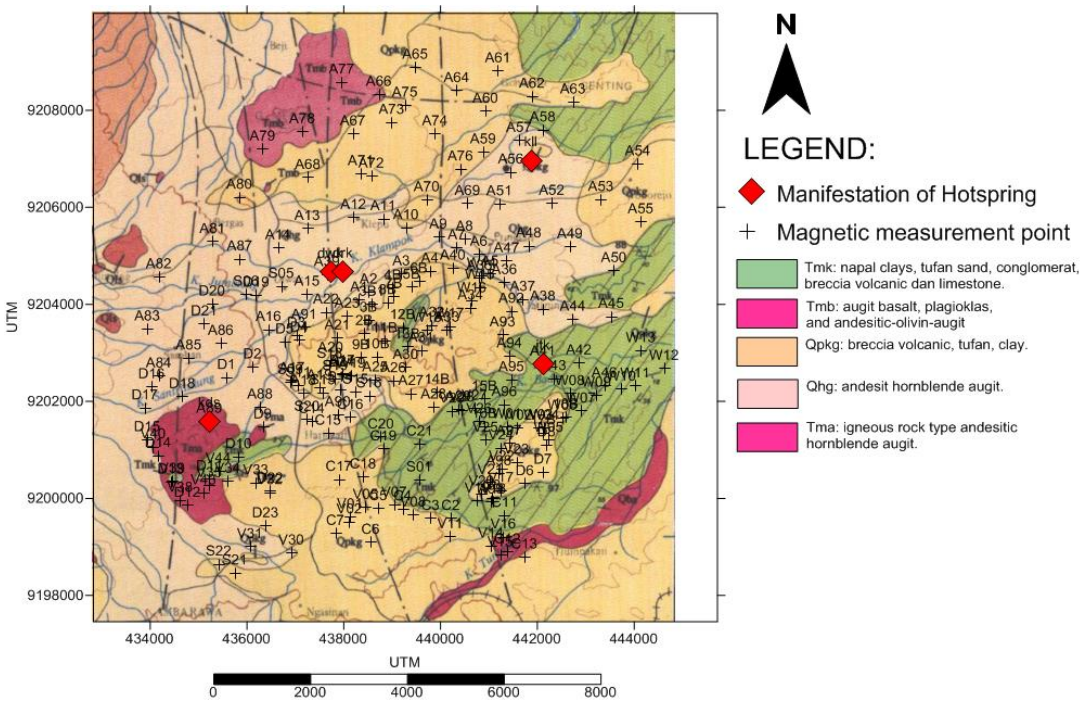


Figure 1. Geology Map [7]

The survey area can be divided by some lithological pattern [7]. Each of them will be grouped as sediments and volcanic classes. The sediment class, consist of Kerek Formation (Tmk: napal clays, tufan sand, conglomerat, breccia volcanic dan limestone) and Kaligetas Formation (Qpkg: breccias volcanic, hornblende augit). The volcanic rock, they are Basalt igneous rock (Tmb: augit-basalt, plagioklas, and andesitic-olivin-augit), Gajah Mungkur volcanic rock (Qhg: andesit hornblende augit), and andesitic igneous rock (Tma: andesitic hornblende augit).

In the regional structural geology, the survey area is a part of tertiary sediment at the Central depression zone that has filled quarter sediment. According to (Fig.1) we can see that there were two fault patterns. The first, northwest to southeast and moved to north to south, and fault pattern in the southwest to northeast that indicating Klampok River which is Diwak and Derekan hotspring has been located.

## Result and Discussion

3D modeling results are presented as a slice on the Fig.2 from northwest to southeast. The slicing across Diwak-Derekan hotspring and Jatikurung hotspring (that also found intrusion rock). According to the model we interpreted that Diwak-Derekan geothermal system is a geothermal system which has a separated reservoir system with Jatikurung hot spring. The Diwak-Derekan's reservoir are located at about 3500 – 4000 meter depth and Jatikurung's reservoir has about 1600 – 2000 meters depth. The model shows that they consist of a heat source, the lowest susceptibility has -0.158 (SI) at about 6000 meters depth. Figure 2 shows that there are complex structure of the subsurface. The differentiation of high and low susceptibility is so clear and can we interpret there are some active fault and make transport the fluids from meteoric to the subsurface and mixed with hydrothermal fluids and transport to be manifestation of hotspring in Diwak-Derekan and Jatikurung. In the Jatikurung hotspring manifestation, we also has found intrusion rock. The intrusion of the rock is one of indicator that there are heat source zone under the surface.

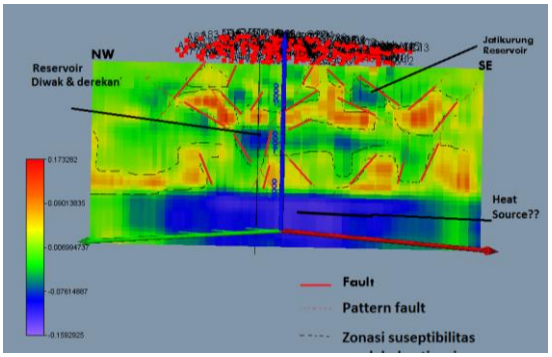


Figure 2. 3D magnetic inversion modelling sliced with arrow northwest to southeast.

According to Fig.3 we had sliced 3D modeling with arrow from northeast to southwest. The slice across the Kaliulo hotspring, Diwak-Derekan hotspring, and Kendalisodo hotspring. We can interpret the reservoir of the Diwak-Derekan in the 3500 to 4000 meters of depth and Kendalisodo in the 2000 to 4000 meters of depth. Although they have different reservoir, but they have same heat source. The heat source interpreted in the more than 6000 meters. Kaliulo hotspring manifestation doesn't have reservoir of the hydrothermal fluids. The manifestation has appeared from interaction of the structure fault that from pattern fault a row with Lutung river and make a hotspring appeared in the Kaliulo manifestation. From figure that there'is contrast susceptibility from high and low susceptibility and we interpreted that there is a fault that caused the hotspring appeared in the Kaliulo manifestation.

We had sliced 3D modeling (Fig.4) at west to east that across Kendalisodo and Jatikurung hot spring manifestation. We interpret that the Kendalisodo reservoir zone is located at 2000 to 4000 meters depth. But in the eastern of the Kendalisodo's reservoir, we get the result that is a same susceptibility value with Kendalisodo's reservoir and that is bigger potential than Kendalisodo's reservoir. That reservoir connected with same heat source of Kendalisodo's reservoir. That reservoir also connected to fault of Jatikurung hotspring manifestation and intrusion rock on the surface. We can interpret that reservoir is Jatikurung's hotspring that has 2000 to 5000 meters depth. Based on magnetic 3D modelling and the field geological data, a speculation shows that magnetization intensity assumed for the existence of a cooling magma intrusion is suggested at the southern part of the study area that is located at Sajen Village.

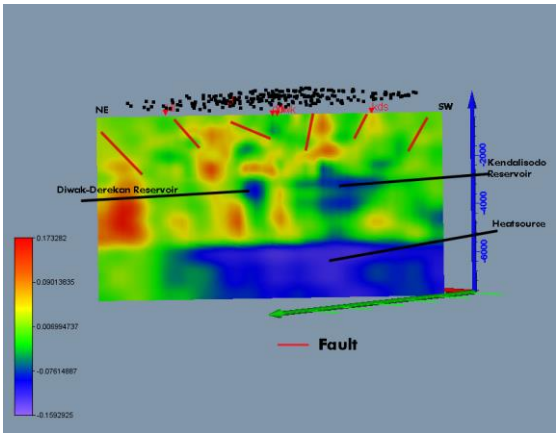


Figure 3. 3D magnetic inversion modelling sliced with arrow northeast to southwest.

ISSN: 978-602-71169-7-9

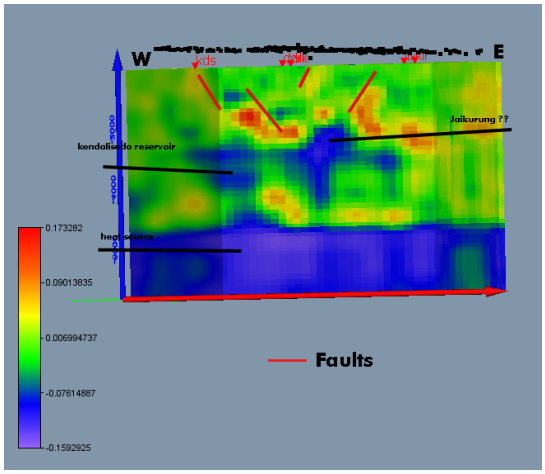


Figure 4. 3D magnetic inversion modeling sliced with arrow west to east.

## Conclusion

We interpreted 3D magnetic data surrounding Diwak-Derekan geothermal manifestations. Almost all of the geothermal manifestations are found as hot springs, there are Kendalisodo, Jatikurung, and Kaliulo hot springs. The evidence of the hot springs coincide with the lineament of the faults. The southern part of Jatikurung hot springs, that is Sajen Village, we have an intrusion rocks which is correlated to the 3D magnetic section as low susceptibility zone and we interpreted as heat source.

The results of 3D magnetic sections that sliced at the northeast to southwest does not show any low susceptibility part under the Kaliulo hot spring, we interpreted that the hot springs system come from the fault structure as a high permeability zone that transported hydrothermal fluid from surrounding reservoir, such as Derekan geothermal system. Diwak, Derekan, Kendalisodo and Jatikurung geothermal hot springs has a specific reservoir system, which is each of them as a separated reservoir, but the heat source looks like have one system.

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