Identification Distribution of Hot Spring in Cisarua Using Magnetic Method

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Abstract. Lampung is one of the provinces which have hot spring resource. One of the unique hot springs in Lampung is Cisarua hot spring. Its location is far from volcanic which makes researcher curious with the system of hot spring from Cisarua. Based on the geology map, the location of hot spring is in Lampung Panjang Fault. The aim of this research is to know about type, zone and distribution of hot spring. The method used in this research is magnetic method with combined geochemistry. From geochemical analysis, the type of hot spring in Cisarua is bicarbonate water. It correlates with outflow and shallow zone. Based on 3D modelling of low magnetic anomaly, distribution of hot water is in Center and Southeast research area. Hot water is interpreted by low anomaly.

1. Introduction
Sumatra is an island that has the largest geothermal potential in Indonesia. There are about 93 geothermal locations spread from Aceh to Lampung. Most geothermal systems correlate with volcanoes. There is a unique geothermal location in Lampung, which does not correlate with the volcanic system but is correlated with fault structures. This geothermal system is located in Cisarua, Natar District, Lampung.

There are a number of geothermal studies that have been carried out in Lampung such as Permatasari et al. [1] investigated subsurface from the Rendingan-Ulu Belu-Way geothermal field by using the gravity method. From this study, the results obtained that the reservoir system heat source comes from Quaternary diorite intrusion. Iqbal et al. [2] examined the recharge areas of hot springs in Natar. Based on the topography, the recharge area is located in the Western and Southern parts of the Metro-Kotabumi Groundwater Basin.

Based on research by Suharno et al. [3], the Cisarua hot spring correlates with the Lampung Panjang Fault. Research by Suharno et al. [3] is limited to visual observations but still has not made measurements using magnetic methods. In this study, researchers identify the distribution of hot springs at the subsurface using magnetic methods that are equipped with geochemical data.

2. Methods
The method used in this research is a magnetic method with geochemical tests. Magnetic measurements are carried out using the GSM19T Magnetometer tool around Cisarua hot springs, Natar District, Lampung. The location of hot springs can be seen in Figure 1. The area is around 175 m x 225 m = 39,375 m². The number of magnetic measurement points is about 93 points with a grid about 25 m. Magnetic survey design is shown in Figure 2. These magnetic measurements are used to model the subsurface of Cisarua hot spring.
In addition to magnetic measurements, researchers conduct geochemical tests. The elements tests include Na, K, Ca, Mg, Cl, SO$_4$, and HCO$_3$. These elements are used to determine fluid type and reservoir temperature estimation. Water samples are taken at the new Cisarua hot spring.

![Figure 1. Map of the location of the Cisarua hot spring, Natar.](image1)

![Figure 2. Design of magnetic survey is in the Cisarua hot spring, Natar.](image2)

3. Results and Discussion

Based on geological maps [4], the Cisarua hot springs are in the Lampung Panjang Fault. Plot of Ternary diagram [5] shows that the Cisarua hot springs have a bicarbonate of water type which are associated with shallow reservoir zones and outflows. Then, Na-K-Ca geochemical test gives information that the Cisarua hot spring has a reservoir temperature of around 219 °C.

The results of magnetic data processing are plotted in Figure 3 (left). Low anomalies indicated by blue colour with value of 60 until 120 nT. Low anomalies look around new hot springs. To eliminate the effects of dipoles, researchers conducts reduce to pole (RTP). The RTP result is in Figure 3 (right).
After being assigned to RTP, researchers conduct 3D modelling. The results of 3D modelling of low magnetic anomalies from the Cisarua hot springs can be seen in Figure 4. The distribution of subsurface hot springs is interpreted to correlate with low magnetic anomalies. Based on the low magnetic anomaly in Figure 4, the distribution of subsurface hot water is in the Central to Southeast part of the study area.

Based on drill data on hot springs, it was found that the depth of hot water was around 20 m. This is consistent with 3D models of low magnetic anomalies and geochemical data. The researcher interprets that the new and old hot springs are connected by the Lampung Panjang Fault.

4. Conclusion
The Cisarua hot water type is bicarbonate which is associated with shallow and outflow reservoir zones. The depth of this hot spring is around 20 m. The distribution of subsurface hot water shown by a low anomaly in blue colour (see in Figure 4) that is scattered in the Central and Southeast research areas. New and old springs are connected by the Lampung Panjang Fault.
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