MULTIMETHOD APPROACH TO THE STUDY OF SUBSURFACE IN MERAK BATIN HOT SPRING, NATAR, LAMPUNG

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Abstrak. Air panas Merak Batin Natar adalah sebuah manifestasi panas bumi di Lampung yang cukup menarik karena terletak cukup jauh (16 km) dari tubuh gunung berapi terdekat di Lampung. Sampai saat ini, mekanisme produksi panas bumi di Merak Batin Natar belum pernah dipelajari secara mendalam.Tujuan dari penelitian ini adalah untuk mendapatkan model bawah permukaan dari mata air panas Natar. Metode yang digunakan adalah kombinasi metode magnetik, geolistrik dan geokimia. Berdasarkan hasil penelitian didapatkan bahwa model bawah permukaan dari mata air panas Natar terdiri dari zona tidak teralterasi dan teralterasi. Mata air panas ini termasuk zona outflow sehingga wajar jika berada di dataran rendah dan jauh dari gunungapi.
Kata Kunci: mataair panas, magnetik, geolistrik, Lampung

Abstract. *Merak Batin Natar hot spring is a geothermal manifestation located far (16 km) from the nearest volcanic edifice and thus is of local scientific interest. The driver of this hot spring has never studied in detail, and whether this system links to the distant volcanic body is an open question. The purpose of this study was to obtain a subsurface model of the Natar hot spring. The method used is a combination of magnetic, geoelectric and geochemical methods. Based on the results of the study, it was found that the subsurface model of the Natar hot spring consists of an unaltered and altered zone. This hot spring belongs to the outflow zone, so it is natural to be in the lowlands and far from the volcano.*
Keywords: *hot springs, magnetic, Lampung*

INTRODUCTION

Natar hot springs are very interesting because these hot springs are in the lowlands, which can be seen in Figure 1. The distance separating the Merak Batin Natar (MBN) hot spring from the nearby volcano (16 km) makes any possible linkage between this geothermal system to volcanism not directly obvious. To answer this problem, researchers need to apply several earth methods such as magnetic, geoelectric and geochemical.

The methods that are often used for initial geothermal surveys are magnetic (Abraham et al., 2014; Pandarinath et al., 2014; Timur, 2014) and gravity (Martakusumah et al., 2015; Atef et al., 2016). Meanwhile, the method that is often used to identify rock resistivity is geoelectric (Usher et al., 2000; Abera and Mizunaga, 2017). To get the type of hot water and reservoir temperature, geochemistry can be used (Purnomo and Pichler, 2014; Purnomo and Pichler, 2015).

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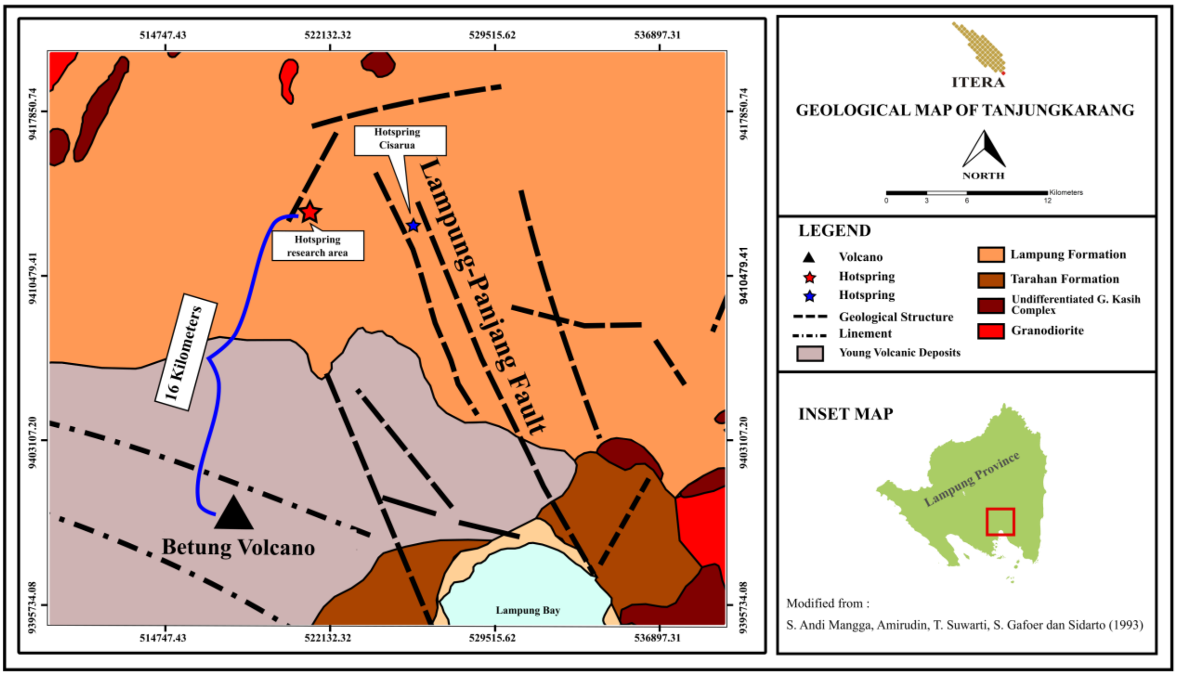

Figure 1. Location of the research area (Mangga et al. (1993) modified)

There are several studies that have been conducted in this hot spring such as Iqbal et al. (2019) using a topographic map to obtain the recharge area of the Natar hot spring which originates from Mount Betung. Furthermore, Juliarka and Iqbal (2020) used the gravity method to find faults where it was found that the dominant Natar hot water discharge came from the fault lines trending northwest-southeast and north-south. Santoso et al. (2020) used a gradiometer to detect the flow of hot water. Based on previous studies, researchers only use topographic maps, gravity methods and gradiometers but have not used a combination of other geophysical methods. Therefore, this researcher will apply a combination of three methods, namely magnetic, geoelectric and geochemical for subsurface studies of Natar hot springs.

METHODS

Natar is one of the sub-districts in South Lampung. Based on the Geological map of the Tanjung Karang Sheet in Figure 1, the Natar lithology is divided into three formations. The widespread Quaternary Lampung Tuff (QTl, Fig. 1) which overlain the Cretaceous. Distribution of Sekampung Foliated Diorite (Kds) covering the Paleozoic. Trimulyo Marble (Pzgm) has a Paleozoic age. If sorted by age from oldest to youngest are Pzgm, Kds and QTI which means that marble and schist are formed due to interactions with diorite magma intrusions. After that, the two rocks were covered by tuff which is the result of a volcanic eruption whose source is still unknown.

The location of the data acquisition area can be seen in Figure 1. This location is in Merak Batin Village, Natar District, South Lampung. In this location, two hot spring manifestations were found, namely N1 and N2. The methods used in this study include magnetic, geoelectric, and geochemical. The area of magnetic acquisition is about 200 m x 275 m. The design of the magnetic and geoelectric survey can be seen in Figure 2.

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There are 102 magnetic measuring points with 25 m spacing of measurement points. While the geoelectrical measurement consists of 3 lines, line 1 has a length of 105 m with a space between the electrodes of 3 m. Line 2 has a length of 70 m with a space between the electrodes of 2 m. Line 3 has a length of 105 m with a space between the electrodes of 3 m.

Magnetic and geoelectric measurements using equipment from the UPT Laboratory of Institut Teknologi Sumatera, magnetic measurements were carried out using the GEM-GSM19T Magnetometer to obtain the total magnetic field intensity. Geoelectric measurements were carried out using the ARES 1 v.5 tool with Wenner-Alpha electrode configuration to obtain apparent subsurface resistivity. The geochemical test was carried out at the Water Quality Laboratory of the Faculty of Civil and Environmental Engineering, Bandung Institute of Technology. The elements/minerals obtained are Cl, SO4, HCO3, Na, K, Mg. Geochemical test samples taken at two asterisk points can be seen in Figure 2.

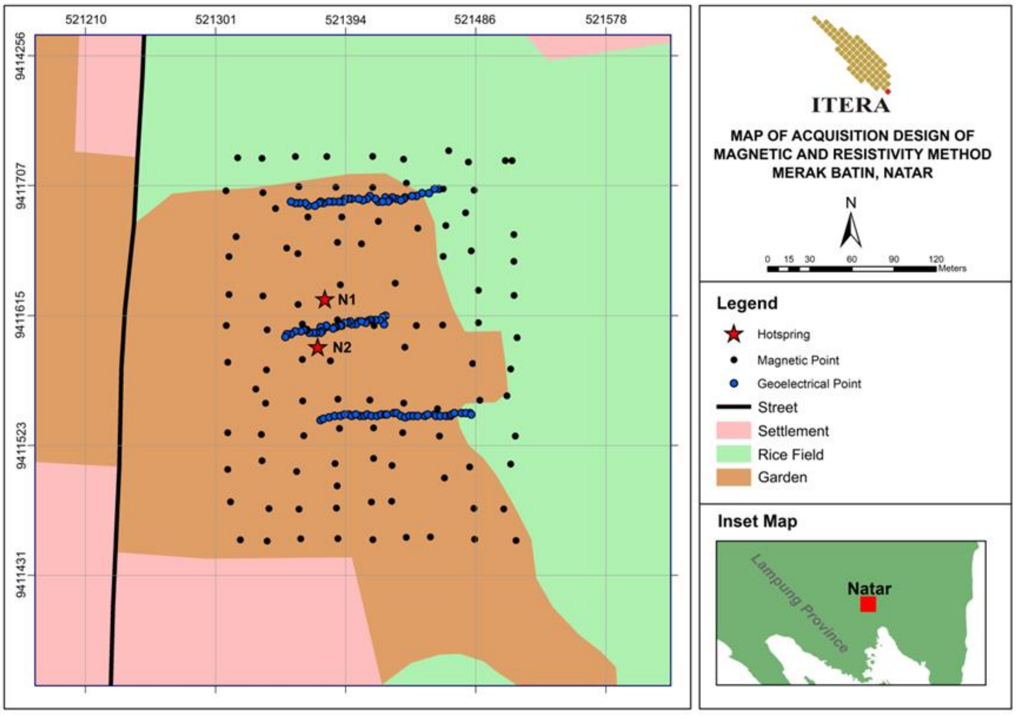

Figure 2. Research data acquisition survey design

RESULTS AND DISCUSSION

In magnetic measurements obtained the value of the total magnetic field. This total magnetic field value is corrected by diurnal variations to remove the magnetic field effects from daily magnetospheric and solar wind dynamics and the International Geomagnetic Reference Field (IGRF) correction to eliminate the effect of the main magnetic field so that only the total magnetic intensity (TMI) remains, then further processing is carried out. From the TMI map in Figure 3, it is found that low anomalies are found around the manifestations of N1 and N2.

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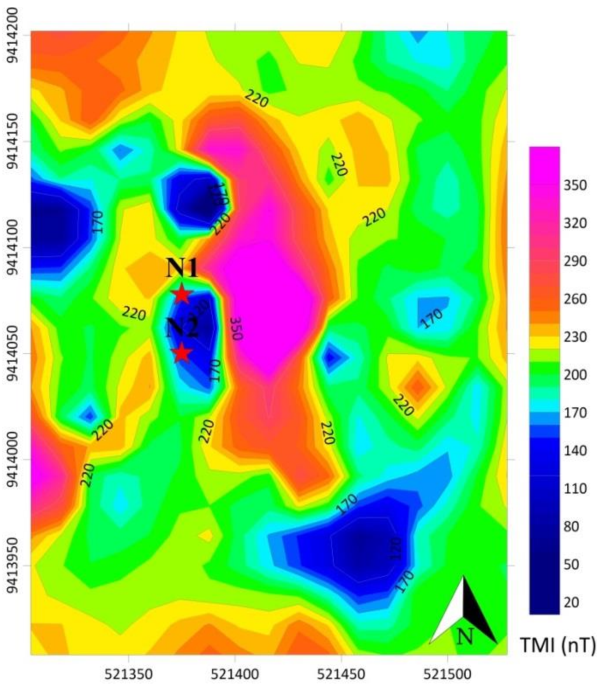

Figure 3. TMI map

To eliminate the dipole effect, proceed with change the inclination on the TMI map to 90 degrees. After doing the RTP, it can be seen in Figure 4, the location of the low anomaly is getting clearer to the location of the hot springs. Furthermore, the RTP map is separated using a Gaussian filter to obtain regional and residual anomalies maps (can be seen in Figure 5). It can be seen on the regional and residual maps, that there is a low anomaly shift which was initially in the Northeast and West of the hot spring manifestation (see regional map) to be around the hot water manifestation (see residual map).

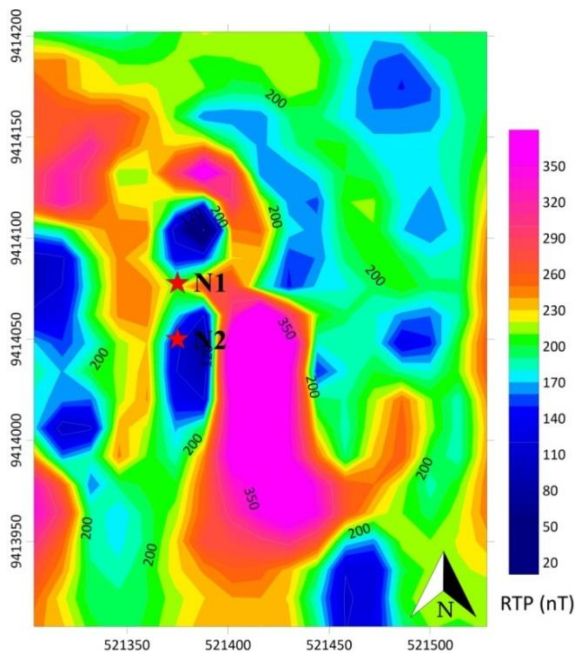

Figure 4. RTP map

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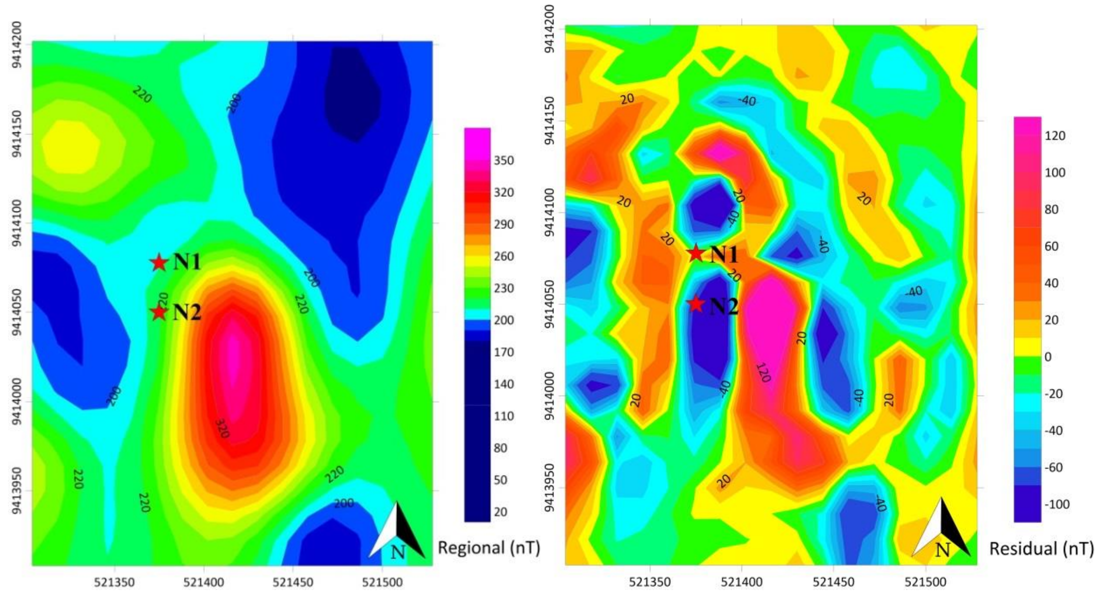

Figure 5. Regional (left) and residual (right) anomalies maps

After that, the RTP map is further processed using 3D modeling software by inputting magnetic susceptibility parameters, with a lower bound of approximately -0.005 SI and an upper bound of about 0.005 SI. The mesh is kept constant in order to obtain the distribution of magnetic susceptibility in the area. Magnetic 3D modeling can be seen in Figure 6. Then, from Figure 6 only low anomalies are shown so that the distribution of low magnetic susceptibility anomalies in that area is obtained see in Figure 7.

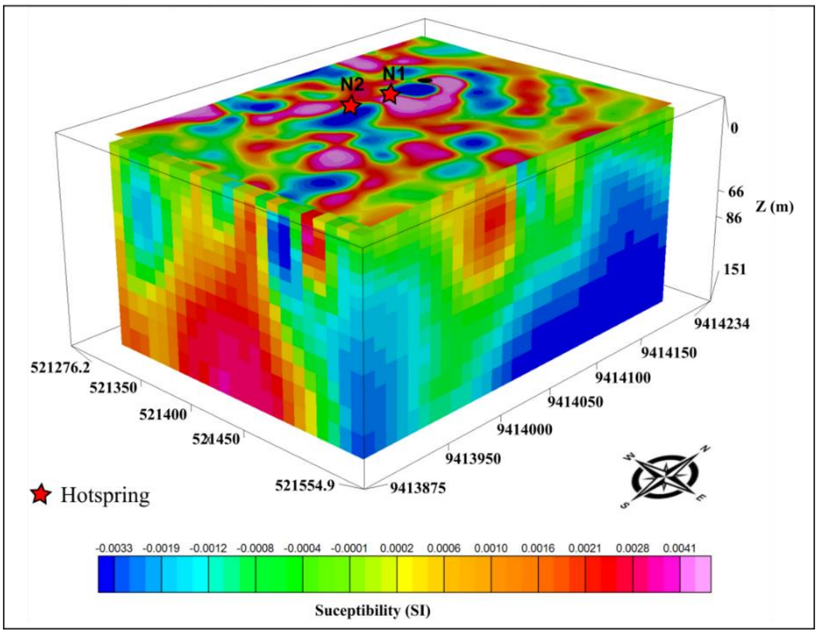

Figure 6. 3D magnetic modelling

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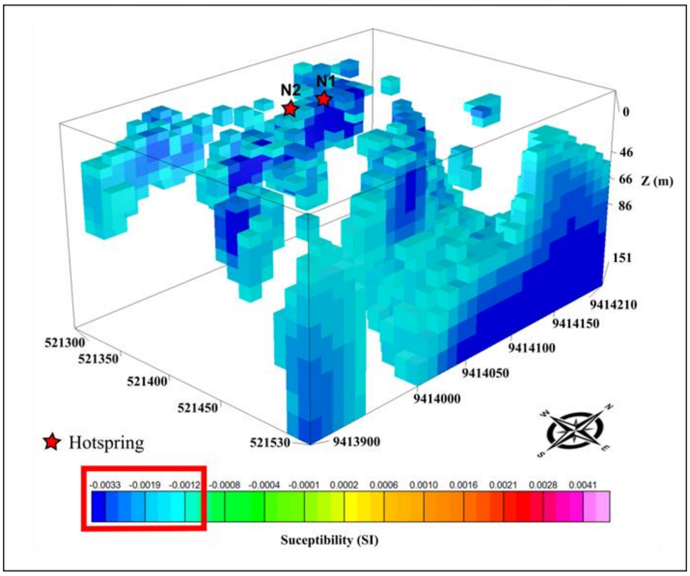

Figure 7. 3D low magnetic susceptibility modelling

Meanwhile, geoelectric data is processed using Res2Dinv software to obtain a 2D resistivity cross section in Figure 8. The parameters entered are constant mesh and resistivity with the smoothness constrained least square inversion method (Geotomo Software, 2010). In general, it can be seen in Figure 8, the subsurface model of the manifestation of hot water consists of 2 layers, namely a tuff layer with a resistivity value above 7 ohm.m (non-alteration zone) and a clay layer with a value below 7 ohm.m (alteration zone). From the 3 lines in Figure 8, interpolation was performed using 3D modeling to obtain the 3D distribution of resistivity can be seen in Figure 9.

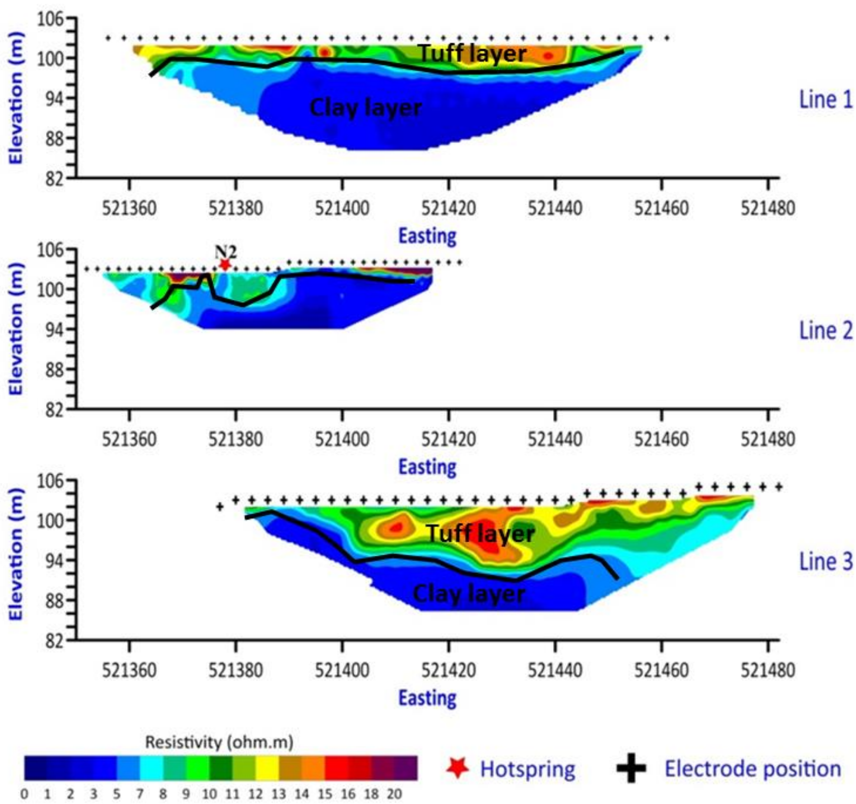

Figure 8. 2D resistivity of cross section

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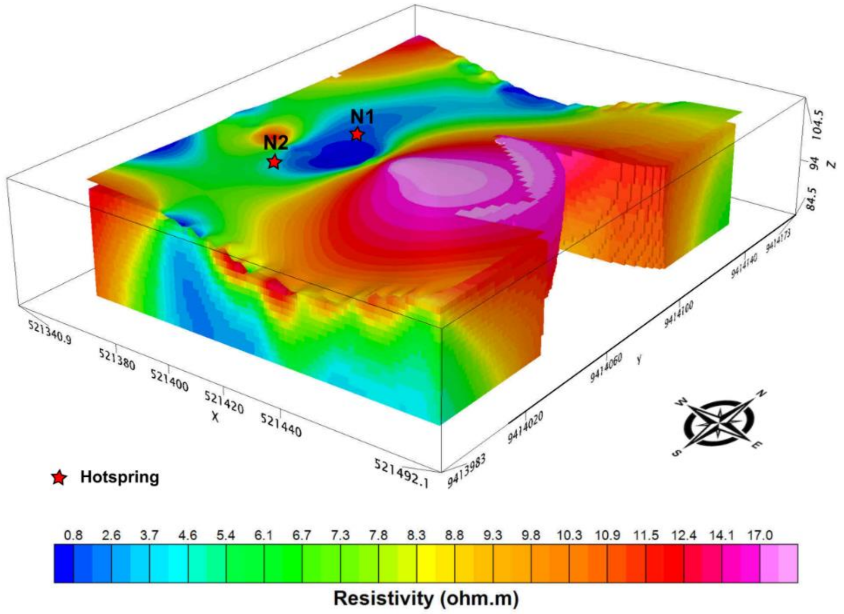

Figure 9. 3D resistivity modelling

To clear interpretation, the distribution of high resistivity in Figure 9 is omitted because the high resistivity is thought to be a non-alteration zone. Seen in Figure 10, the distribution of low resistivity refers to the distribution of the alteration zone. In this alteration zone, it is suspected that there are faults as the outlet for the manifestation of N1 and N2 hot water.

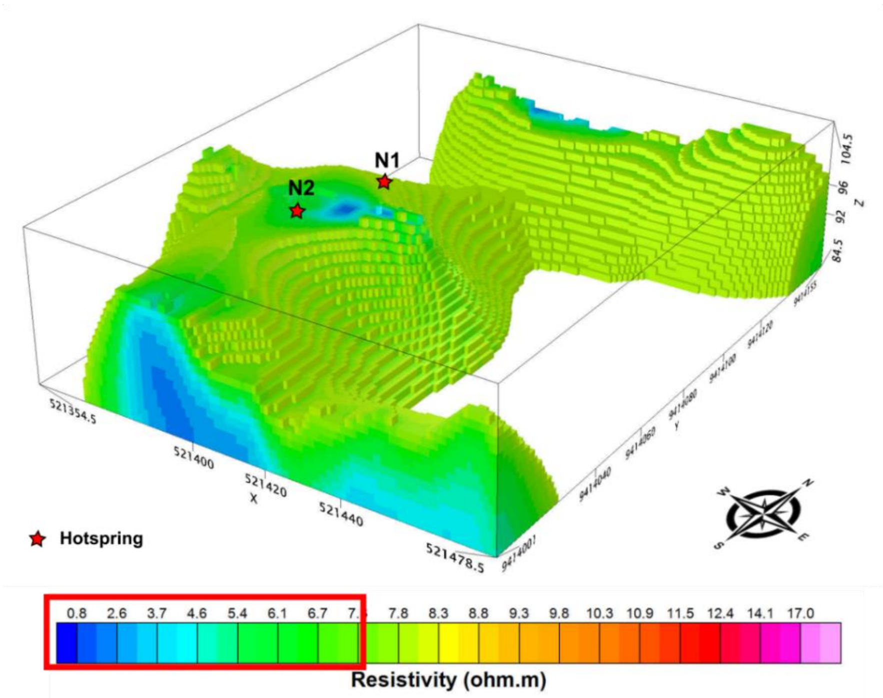

Figure 10. 3D low resistivity modellin

Based on Abera and Mizunaga (2017), the low resistivity of less 7 ohm.m in this study area can be interpreted as an argillic zone dominated by smectite/illite minerals (clay cap). To obtain the depth

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distribution of the argillic alteration zone, magnetic 3D modeling was used. The distribution of the argillic alteration zone is shown by the low anomaly in Figure 7.

After we get the distribution of argillic alteration zones in the subsurface model of Natar hot springs, the researchers are curious about the type of hot springs. Based on the Ternary Diagram, Cl-SO4-HCO3 in Figure 11, the type of hot water from the Natar hot spring is bicarbonate. This type of hot spring indicates that the Natar hot spring is included in the outflow zone. So, it is natural that this hot spring is far from the volcano.

Based on these results, we can then deduce the upflow zone with the geological map of the Tanjung Karang Sheet (Mangga et al. 1993) obtained two possibilities that are Betung Volcano (volcanic geothermal system) and through Lampung Panjang Fault (non-volcanic geothermal system). To find out, it is necessary to carry out further geophysical and geochemical tests.

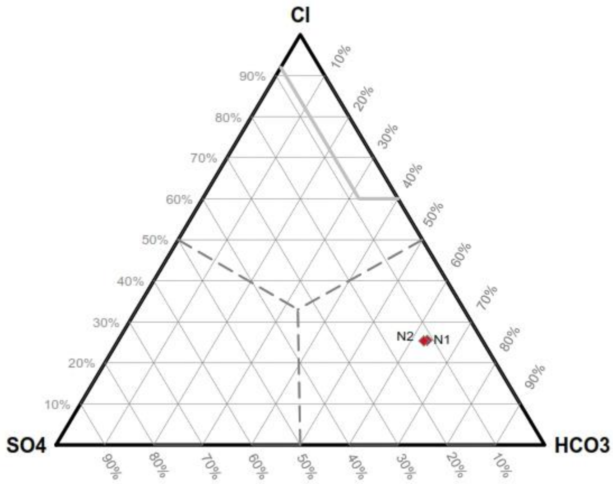

Figure 11. Ternary diagram of Cl-SO_4-HCO_3

To obtain the reservoir temperature, geochemical tests were carried out. Based on the Na-K-Mg geochemical test on this hot spring, it can be seen in Figure 12 that this hot spring has a reservoir temperature of around 240-260°C. If calculated with a Na-K geothermometer it is around 250°C. According to Haenel et al. (1988), such a large reservoir temperature is included in a high-temperature geothermal system.

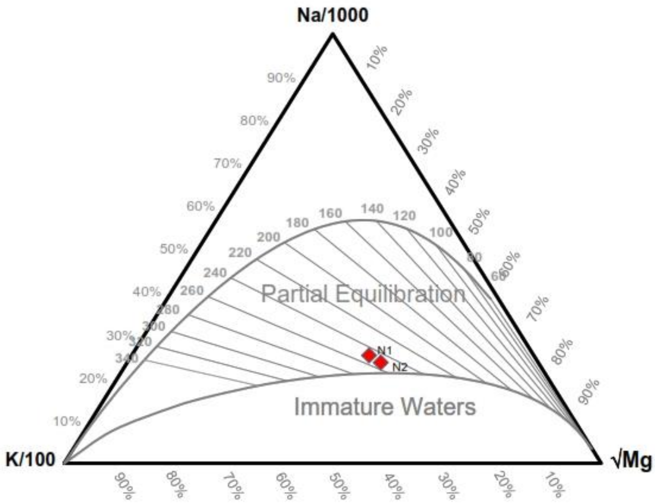

Figure 12. Ternary diagram of Na-K-Mg

CLOSING REMARKS

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Conclusion

The subsurface model of the Natar hot spring consists of a non-altered zone and an alteration zone. The alteration zone is in the form of an argillic alteration zone which is dominated by scemetite/illite minerals which are scattered under hot springs and are thought to be clay caps. The type of Natar hot spring is bicarbonate with a reservoir temperature of 250°C. This type of hot spring indicates that the hot spring is located in the outflow zone. So, it is natural to be in the lowlands and far from the volcano.

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