Preliminary Geomagnetic Study of the Hot Spring Area in Rokan Hulu, Riau - Indonesia

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Abstract. Hot spring is commonly found in volcanic mountain areas. But in Rokan Hulu, a hot spring is found at a distance of about 15 km from the hills of Bukit Barisan. This study aims to conduct a physical study especially preliminary geomagnetic study of the Hot Spring in terms of the magnetic properties and topography of the area. As much as 26 points of the geomagnetic survey were conducted and used in this study. Some data corrections were applied to the data for making the reliable data interpretation. The results showed that there was a weakening of the magnetic field in the zone around Hot Spring itself and the low magnetic value was extended to the Southeast zone of Hot Spring. Topography shows the zone in this southeast has a height difference of fewer than 10 meters from the location of the Hot Spring. Allegedly this weak Magnetic zone is the source of heat from the Hot Spring.

1. Introduction
Hot spring is a location where it releases hot water from the ground to the surface. A hot spring can come out of a hilly wall or out of a relatively flat ground [1]. A hot spring is a source of the geothermal, which is an alternative resource and has the potential to be produced in Indonesia. This is because Indonesia has 129 volcanoes that have the potential to be geothermal development areas. However, not all hot springs are directly related to volcanic activity [2].

The hot spring in Rokan Hulu, Indonesia was found going out from the ground on the edge of a hill that only had a height of several meters. This hot spring area is about 15 km from the top of the hill line with the highest peak is around 1023 meters above sea level. Figure 1 is a photo of Rokan Hulu's hot spring location taken from Google Earth. In Figure 1, it shows that the research area is still covered by relatively thicker secondary forests. About 1200 meters from the hot spring towards the southeast, there is an artificial lake dammed that it was developed by the local government.

The geophysical methods are used to be applied to determine the physical properties of rocks that are below the surface. The anomaly of rock physical properties can be used to estimate the existence of subsurface geothermal systems. In helping to interpret the geothermal potential of the research area, the geophysical data is very helpful in detecting the presence of heat sources, the existence of reservoir zones, and permeable zones [3].

Geomagnetic methods are commonly used in the earth exploration. In geothermal exploration, the magnetic method is used to determine variations in the magnetic field in the study area. The variation of magnetism is caused by nonhomogeneous magnetic properties of the earth's crust. Where rocks in geothermal systems generally have low magnetization compared to surrounding rocks. This is due to the demagnetization process by hydrothermal alteration processes, where the process converts existing minerals into paramagnetic or even diamagnetic minerals [3]. In addition to the magnetic method, the
The geoelectrical resistivity method can also be used to detect the presence of water accumulation or possible fractures in hydrothermal system studies, groundwater potential study and other environmental study [4-6].

In this study, it will be examined the use of magnetic methods to detect the possibility of the presence of heat sources around the hot spring in Rokan Hulu, Indonesia.

![Google Earth capture image of the research area](image)

Figure 1. Google Earth capture image of the research area

2. Methodology

2.1. Magnetic Field of the Earth

The use of the magnetic method is to determine the magnetic field variations in the study area. This variation in the magnetic field is caused by the magnetic properties of the constituent materials of the earth which are different in their physical property. Magnetic methods are very sensitive to vertical changes such as intrusion, the presence of hydrothermal containing ferromagnetic minerals and other geological structures. Magnetic methods can be used in geothermal studies because ferromagnetic mineral minerals will lose or reduced their magnetic properties when they experience heat near the Curie temperature [7].

The earth's magnetic field is a field where magnetic force distribution can be detected. Gauss, a physicist conducts a harmonic analysis of the earth's magnetic field to observe its properties, indicating that the intensity of the earth's magnetic field is almost entirely from within the earth. The terrain observation on the surface of the earth can be approached by the harmonic equation relating to the bipolar potential at the center of the earth. The polar observed by Gauss has a slope of approximately 11.5° against the geographical axis [8]. The source of the earth's magnetic field is generally caused by three factors, namely the main magnetic field of the earth, the outer field, and the anomalous magnetic field.
2.2. Data Acquisition
In this research, PPM Type T of magnetic field detector was used. The equipment was useful to detect the distribution of the magnetic field and will be used to interpret the possibility presence of heat sources around the hot spring in Rokan Hulu, Indonesia. The data retrieval location, latitude and longitude were marked using the Garmin Vista GPS. Data collection was carried out almost evenly with a distance of around 500-1000 meters. The thick secondary forest condition in the field was becoming main obstacle in producing a rectangular gridding of data collection. Figure 2 is an elevation map of the study area. The height of the hot spring location is around 85 m above sea level (asl). In Figure 2, it also shows the location of data retrieval which is marked with a white dot. The data reading was done for around every 30 minutes.

2.3. Data Processing
The magnetic data obtained in the field was processed by making daily variation corrections and IGRF (International Geomagnetism Reference Field) corrections [9]. Both of these corrections are useful for reducing measurement data from the influence of the earth's main magnetic field and the external magnetic field, so that the total magnetic anomaly data generated by magnetic minerals composed of rocks below the surface is obtained. The magnetic data obtained was not corrected to the back cover because the study area is almost at the equator. Furthermore, the anomaly data of total magnetic fields was presented in the form of magnetic contour maps for interpretation.

3. Results and Discussion
The use of the magnetic method is to determine the magnetic field variations in the study area. This variation in the magnetic field is caused by the magnetic properties of the constituent materials of the
earth which are different. The total magnetic field data is the value of the magnetic field at a point produced by the target subsurface rock.

Figure 3 is the total magnetic data after correction the correction applied. In Figure 2 there is no visible polar contour pattern of positive and negative anomalies. The main cause is due to the research area is relatively small, which is less than 9 km². This magnetic map shows the maximum value of the magnetic field is 130 nT and the minimum is 65 nT. The magnetic value is not big in the variation which is indicated that the rock is not big in magnetic property.

The contour map of the total magnetic field (Figure 3) shows that the anomalous data obtained is most likely still located following the topographic plane, so that it will cause errors when interpreting. Therefore the magnetic data must be transformed in a field with the same height \[10, 11\]. Ambiguity may be greater if an uneven field is interpreted, due to the height of the measurement data. However in this paper the correction in question was not done due to the height difference of the area is not too high, it is just in a few meters.

In general there is a relatively low magnetic zone observed in the hot spring location itself and this weak magnetic zone is directed towards the southeast. From this map the dominant weak zone is seen in the two reading locations. It does not rule out the possibility that these locations are a relatively hot zones. The possibility of a heat source from intrusion is very potential, because in this study area it was found that there was igneous rock \[12\] at the southeast direction from the hot spring. Therefore the appearance of hot spring in this research area may be caused by a faulting or rock fracture, so that the hydrothermal fluid can come out to the surface through the formed fault or fracture zone of the rock. This can be seen from the appearance of trends on topography maps (Figure 2), which is the direction of high topography towards southeast. In general, the heat carried by breakthrough rocks then heats ground water trapped in a porous and permeable layer thus forming a geothermal reservoir system. The hot water then rises to the surface through a weak structure and zone which eventually appears as a manifestation of the hot water. Based on the existing geological map the study area
consisted of carbonaceous shale, clean quartz sandstones, siltstones and conglomerate (Sihaspas formation). In addition to other formations (Terisa formation) is consisting of calcareous to carbonaceous siltstones, silty sandstone and shale, which also found cassiterite-bearing intrusion of pegmatites, granites and granodiorites with zones of cataclasis [13]. So if it is correlated with total magnetic field data, it can be seen that there is compatibility with the intensity response of magnetism caused by rocks below the surface.

4. Conclusion

The use of the magnetic method in this research is to determine the magnetic field variations in the study area. This variation in the magnetic field is caused by various factors. Based on the analysis of the total magnetic field anomaly data in the study area, it can be interpreted as a possibility of magnification with relative direction to the southeast, which is a fractured field and becomes the path of geothermal fluid flow to the surface. The results also showed that the magnetic pattern was relatively low in the hot spring zone and spread towards the southeast. The low magnetic value is probably the presence of a relatively high temperature of the rock.

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