INOVASIA (2) (2023) P-ISSN 2964-9420; E-ISSN 2963-2617
Check for updates
INOVASIA
https://jurnal.institutsunandoe.ac.id/index.php/inovasia

DETERMINATION OF SUBSURFACE STRUCTURE BY MAGNETIC METHOD

Indah Gumilang Dwinanda[*1]

[1]Physics Study Program, University of Palangka Raya, Indonesia

Accepted: 21st May 2023. Approved: 13rd July 2023. Published: 30th July 2023.

ABSTRACT

Magnetic method is one of the methods used in geophysical engineering. Measurement using the most widely used magnetic method is by using PPM (Proton Precession Magnetometer). Applications of magnetic methods are often used in preliminary exploration of petroleum, geothermal, and mineral deposits and can be applied to the search for perospection of archaeological objects. The purpose of this study is to determine the subsurface layer using magnetic methods as an initial survey in the hope of applying the theory of magnetic methods in the field before conducting other more complex surveys. The interpretation results based on the mag2dc curve obtained the first object with a depth of 10 meters from the surface, the second object with a depth of between 30 meters from the earth's surface, and the third object with a depth of 20 meters. The fourth object is estimated to be at a depth of 27 meters. The fifth object is at a depth of 32 meters. The sixth object is at a depth of about 35 meters. The seventh object is at a depth of 30 meters. Based on the susceptibility value of rocks, rocks that have a susceptibility value of around -0.1 can be categorized as areas with a majority of quartz or gypsum rocks, 0.05 - 5 consists of pyrite rocks, 0.5 - 35 consists of hematite rocks. It is possible that the first, second, fourth, fifth, and sixth objects are rocks consisting of quartz or gypsum while the fifth object consists of hematite rocks. Or it can be said that the research area consists of minerals in the form of quartz, hematite, calcite, and pyrite.

Reseach Paper

INOVASIA

Keywords: Subsurface, Geophysics, Anomaly Interpretation, Magnetic.

INTRODUCTION

Magnetic method is one of the methods used in geophysical engineering (Sutasoma et al. 2022). Magnetic methods are very helpful for the exploration of mineral resources found in Indonesia. In its development, mineral resources in Indonesia are required to be able to provide maximum benefits (Djuhaepa A. P, et al., 2015). Mineral exploration in Indonesia is certainly in line with President Joko Widodo's goal of implementing Indonesia's development from the periphery by strengthening rural areas within the framework of a unitary state. For this reason, it is necessary to investigate the mineral and geological potential in various regions in Indonesia, one of which is to take measurements using magnetic methods at several points that have the potential to have mineral resources (Syukri 2020).

Basically, earth magnetic investigation is to measure the magnitude of the earth's magnetism caused by various sources, both inside and outside influences, such as solar radiation. Magnetic methods are generally used to determine the magnetic properties of rocks, as well as to determine the subsurface geological structure based on magnetic field anomalies with the intention of creating a magnetic anomaly function with the aim of determining the type of rock and mineral based on its anomalous susseptibility (Panjaitan, 2015; Zulfian 2022).

Measurements using the most widely practiced magnetic method are using PPM (Proton Precession Magnetometer) tools. The magnetic method has advantages in the form

[*]**Correspondance Address**
E-mail: indahgdwinanda@mipa.upr.ac.id

of relatively easy measurement, high-speed data accumulation on a relatively large research area, relatively fast time, and not too large costs (Winda, et al., 2015).

Based on the understanding and function of magnetic methods, magnetic method measurements were carried out in the research area using PPM equipment. The data obtained during measurement include day, date, time, weather conditions, environment, and magnetic field strength, besides that before taking measurements, the determination of base stations and mobile stations with close loop stations is carried out (I N Manyoe, et al., 2020; Umamii et al. 2017). The purpose of this study is to determine the subsurface layer using magnetic methods as an initial survey with the hope of applying the theory of magnetic methods in the field before conducting other more complex surveys.

METHODS

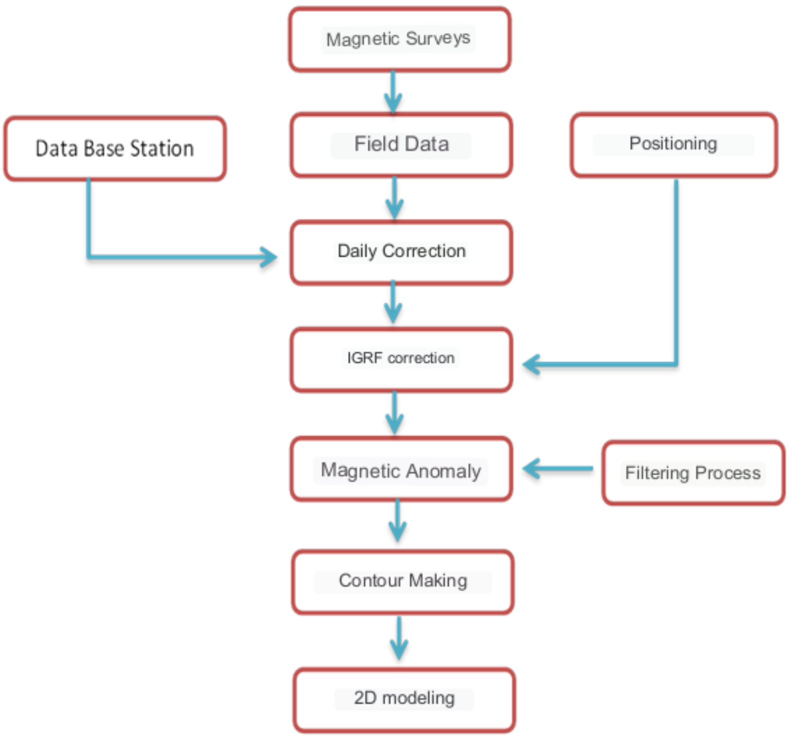

Figure 1 Research Flowchart

This research was conducted with a geographical location around 7°57′21.70 S 112°36'57.42 *T*, with the study area estimated to be around $500 \times 200m^2$ and carried out as many as 20 points with a grid area of $\pm 50m^2$. Measurements with magnetic methods are divided into two stages, namely acquisition and data processing.

The research was conducted by making several corrections including daily correction, IGRF correction, and data filtering process. In the acquisition stage, the equipment used is GPS (Global Positioning System), Proton Procession Magnetometer (PPM), which is equipment used to measure the total magnetic field strength at the survey location. In addition, some additional equipment is a map of the research area (Santosa, et al., 2012). In the magnetic data processing stage, the equipment used is Laptop, Excell Software, SURFER Software, MAGPick, and MAG2DC.

RESULTS AND DISCUSSION

The magnetic data processing process is carried out to see changes in magnetic anomalies in certain areas. Changes in the anomaly value in the form of a spike or a very drastic decrease in the anomaly price. The increase in anomalous prices that are not too high can be due to the weathering process that occurs in the area or changes due to metamorphosis.

The processing process for magnetic data is done by calculating corrections to magnetic data and obtaining the total value of magnetic anomalies. The next processing process is in *Surfer* 10 software to make contours with the X column is *longitude*, the y axis is *latitude* (which has been converted into UTM format) and the z axis is the magnetic anomaly calculated in the Excell software. (Kahfi & Yulianto, 2008).

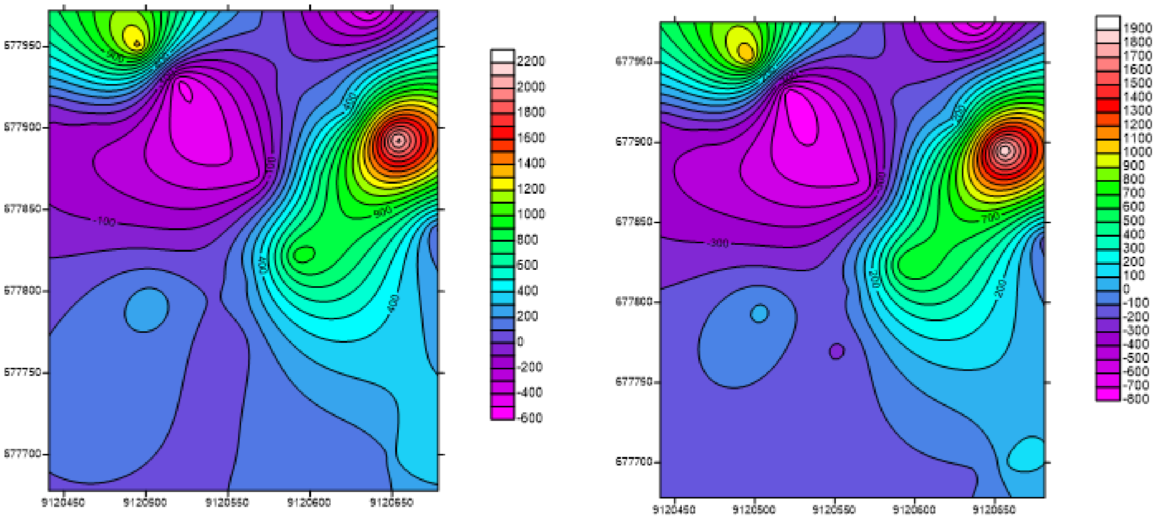

Figure 2 (a) The Contour Map After Upward Continuation, Compared to The Initial Contour Map. (b) There Are Differences Marked with Black Circles in Areas That Experience Differences

The next step is to perform upward continuation on the previously created contour map. There is a clear difference between the contour map that has been carried out by upward continuation and the initial contour map. The use of upward continuation itself is expected to help separate regional anomalies from local anomalies. The process of continuation by trial and error is done by looking at the tendency of the contour pattern of the continuation results at a certain height. The observation data in this study was smoothed to eliminate local effects by upward continuation as high as 500 meters using magpick software.

The total magnetic field anomaly data is then reduced to the poles. Reduction to the poles is one of the magnetic data processing *filters* to eliminate the influence of the magnetic inclination angle (Telford 1990). The filter is needed because the *dipole* nature of magnetic anomalies makes it difficult to interpret field data which is generally still asymmetrically patterned. Reduction to the poles was done using *magpick* software. The results of the reduction to the poles show the magnetic anomaly to be one pole. It is interpreted that the position of the object causing the magnetic field anomaly is below it, where the contour map is produced as follows.

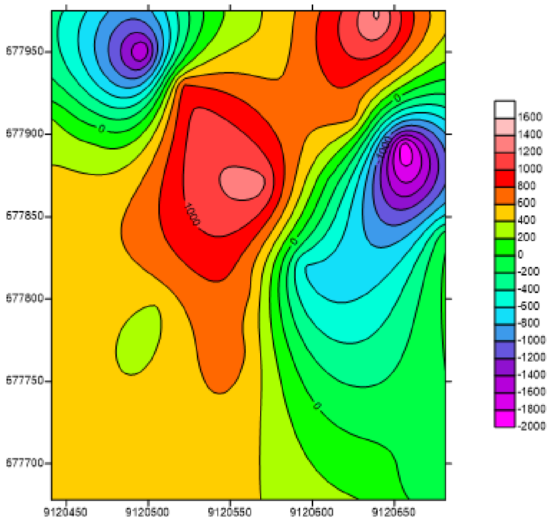

Figure 3 Contour Map After Polar Reduction

Qualitative interpretation is done by analyzing the contours of the total magnetic field anomaly from upward continuation. Reduction to the poles is used to determine the pair of poles that will be used for interpretation. Qualitatively, the anomaly map shows the distribution of anomalous values seen in the *color key* on the contour map in **Figure 3**. The total magnetic anomalies in the research area can be grouped into 3 groups of anomalies, namely (Idral, 2009; Todd 2005)

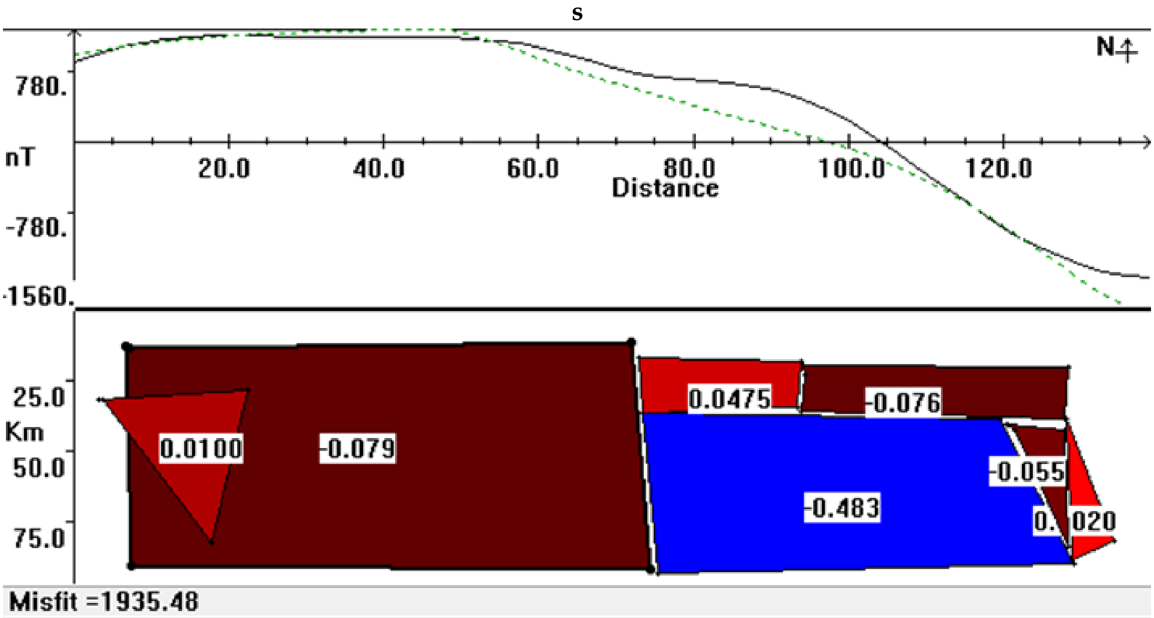

Figure 4 Display Results of Subsurface Modeling Using mag2dc Software

- High positive total magnetic anomaly group with a magnitude of 1,600 nT.
- Moderate positive total magnetic anomaly group with a magnitude of 500 nT to 0 (zero) nT.
- Low total magnetic anomaly group 0 nT to -2000 nT.

The investigation area is generated by a positive-negative magnetic anomaly. Geologically, it is a manifestation that under the surface there are non-magnetic rocks which are interpreted as a manifestation that under the surface there are rocks that have been changed strongly to low. On the anomaly map, negative and positive values can be seen that the contour pattern looks closer, this indicates the presence of a fault structure in the area, because the fault structure is characterized by anomaly lineation, contour density, anomaly deflection, and anomaly mutation (negative and positive).

Quantitative interpretation is done by modeling using Mag2dc software, by entering the intensity, inclination, and declination prices. This modeling process requires additional data in the form of stratigraphic maps and geological maps of the study area. The accuracy of the *Mag2dc* software for modeling is seen from the *missfit* value. The smaller the misfit value, the more accurate the modeling. In this modeling, the *missfit* value is 1935, 48 which is still quite large for an *error value*. With the help of geological information, anomaly-causing objects were modeled. Quantitative interpretation was carried out on the incision results from qualitative interpretation. The modeling for the incision is expected to explain the subsurface structure that may be the cause of the anomaly.

Subsurface modeling (**Figure 4**) obtained subsurface interpretation in the form of 7 rocks that have different susceptibility contrasts with the surrounding rocks. The susceptibility obtained is with a value of (-0.079) cgs for the first object (dark red color), (0.0475) cgs for the second object (red color), the third object (blue color) with susceptibility (-0.483) cgs, for the fourth object (dark red color), (-0.076) cgs, for the fifth object (red color) (0.020) cgs, for the sixth object (dark red color) (-0.055) cgs, and the seventh object for (dark red color), (0.0100) cgs with West-East-West direction.

The first object is 10 meters deep from the surface, the second object is between 30 meters deep from the earth's surface, and the third object is 20 meters deep. The fourth object is estimated to be at a depth of 27 meters. The fifth object is at a depth of 32 meters. The sixth object is at a depth of about

35 meters. The seventh object is at a depth of 30 meters. Based on the susceptibility value of rocks, according to Blakely (1995), rocks that have a susceptibility value of around -0.1 can be categorized as areas with a majority of quartz or gypsum rocks, 0.05 - 5 consists of pyrite rocks, 0.5 - 35 consists of hematite rocks. It is possible that the first, second, fourth, fifth, and sixth objects are rocks composed of quartz or gypsum while the fifth object consists of hematite rocks. Or it can be said that the research area consists of minerals in the form of quartz, hematite, calcite rocks.

Based on the curve in **Figure 4**, it can be indicated that there is a descending fault where the curve has decreased significantly from left to right and when compared to the depth difference between the first rock and the second rock which has a depth difference of 20 meters. This is supported by regional geological data of the East Java Basin, where the East Java Basin is dominated by minor and major descending faults (Ariati et al., 2019).

The results that have been modeled need to be reviewed for information at the time of acquisition. At the time of acquisition there were several acquisition problems, where the research area was directly adjacent to settlements and high-rise buildings, power cables and motorized vehicles that passed by during data acquisition which would cause the recording of rock magnetic values that should be non-magnetic to be affected by the magnetic field contained in electric currents or motorized vehicles.

CONCLUSION

The interpretation results based on the mag2dc curve obtained the first object with a depth of 10 meters from the surface, the second object with a depth of between 30 meters from the earth's surface, and the third object with a depth of 20 meters. The fourth object is estimated to be at a depth of 27 meters. The fifth object is at a depth of 32 meters. The sixth object is at a depth of about 35 meters. The seventh object is at a depth of 30 meters. Based on the susceptibility value of rocks, rocks that have a susceptibility value of around -0.1 can be categorized as areas with a majority of quartz or gypsum rocks, 0.05 - 5 consists of pyrite rocks, 0.5 - 35 consists of hematite rocks. It is possible that the first, second, fourth, fifth, and sixth objects are rocks composed of quartz or gypsum while the fifth object consists of hematite rocks. Or it can be said that the research area consists of minerals in the form of quartz, hematite, calcite rocks.

Author's declaration

Authors' contributions and responsibilities

The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation and discussion of results. The authors read and approved the final manuscript.

Funding

Write down the research funding, if any.

Availability of data and materials

All data are available from the authors.

Competing interests

The authors declare no competing interest.

REFERENCES

Ariati, V. R., Fahrudin, Hidayatillah, A. S., & Widiartha, R. (2019). Subsurface Mapping and Tectonostratigraphic Analysis, Ariati Block, East Java Basin. *Journal of Geosciences and Technology*, 1-12.

Blakely, R.J. (1995). *Potential Theory in Gravity and Magnetic Applications*. United State of America: Cambridge University Press.

Djuhaepa A. P, Musa, M., & Sandra, T. (2015). *Identification of the Distribution of Iron Ore Using the Geoelectric Obstacle Type Method in Ogowele Village, Tolitoli Regency*. Tadulako University.

I N Manyoe, D A Suriamihardja, U R Irfan, S S Eraku, S S Napu, & D D Tolodo. (2020). Geology and 2D modeling of magnetic data to evaluate surface and subsurface setting in Bongongoayu geothermal area, Gorontalo. *TREPSEA. IOP Conf. Series: Earth and Environmental Science*, 589.

Idral, A. (2009). *Geomagnetic method application in determining the potential of iron ore resources in bukit bakar and ulu rabau areas, lembah gumanti sub-district, kab. Solok, west sumatra*. Jakarta: Department of Energy and Mineral Resources Geological Agency Geological Resources Center.

Kahfi, R. A., & Yulianto, T. (2008). Identification of Subsurface Structure of Gold Manifestation

Area Using Magnetic Method in Papandayan Garut, West Java. *Physics Periodical Vol 11*, 127-135.

Panjaitan, M. (2015). Application Of Magnetic Methods In Determining The Type Of Rocks And Minerals. *Journal of Computer Research (JURIKOM) Vol.2 No. 6*, Page 69-72.

Santosa, J. B., Mashuri, Sutrisno, T. W., Wafi, A., Salim, R., & Armi, R. (2012). Interpretation Of Magnetic Method To Determine The Subsurface Structure Around Mount Kelud In Kediri District. *Journal of Physics Research and Its Applications (JPFA)*, pp. 7-14.

Sutasoma, M., Susilo, A., Sunaryo, Suryo, E. A., & Minardi, S. (2022). Analysis Of The Rock Layer Contact Using The Gravity Data Of Satellite Imagery And Resistivity Method. *International Journal of GEOMATE Vol.23, Issue 96*, pp. 69-76.

Syukri, M. (2020). *Introduction to Geophysics.* Aceh: Syiah Kuala University Press.

Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). *Applied Geophysics (2nd ed.).* Cambridge: University Press.

Todd, D. (2005). *Groundwater Hydrology, 3rd Edition.* New York: John Wiley & Sons Inc.

Umamii, A. M., Yulianto, T., & Wardhana, D. D. (2017). Application of magnetic method to identify iron ore distribution in Solok Regency, West Sumatra. *Youngster Physics Journal*, 296-303.

Winda, Herianto, & Sukamto, U. (2015). Geomagnetic Investigation for Iron Ore Estimation of PT Berkah Alam Semesta in Bana Village, Bontacani District, Bone Regency, South Sulawesi. *Journal of Mining Technology*, 1.

Zulfian. (2022). Application of geoelectric method in estimating the thickness of peat soil layer (case study: area around jl. Perdana, pontianak city). *Journal of Physics Coils, Vol. 5No. 1*, pp. 55-62.