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Magnetic Data Processing to Determine The "X" Subsurface Geological Structure

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Abstract: *Magnetic data processing has been carried out with the aim of identifying subsurface structures for interpretation of the presence of faults in the "X" area. The data used in the form of secondary geomagnetic data with a total of 1568 points of measurement. In this research, processing is carried out using standard processing as a reference for the development of numerical processing. From the modeling results, it can be seen the existence of a down-fault. The existence of faults in the research area is a potential for several minerals with promising economic value. The appearance of metallic minerals is in tuff rocks with a susceptibility value of 0.005 emu to 0.007 emu. In addition, there are lapilli tuff, breccia, andesite, and andesitic tuff rocks with susceptibility values of 0.005 emu, 0.001 emu, 0.016 emu, and 0.007 emu, respectively.*

Key Word*: geological structure, fault, total magnetic field anomaly, susceptibility, magnetic method*

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I. Introduction

One of the metal exploration stages is conducting a preliminary geophysical survey to determine the distribution of minerals and subsurface structures. One of the geophysical surveys that is often used is the magnetic method. Magnetic surveys are carried out to determine geological structures, such as faults, folds, igneous rock intrusions, geothermal reservoirs, groundwater aquifers, metal mineral deposits, and others. Through the development of science and technology, many instruments and software have been developed to support magnetic surveying. Thus all stages of activities in magnetic surveys such as data measurement, processing, modeling, and interpretation can be carried out in a relatively short and easy time [1].

In previous studies, the research area was associated with other minerals such as Pyrite (FeS2), Chalcopyrite (CuFeS2), Troilite, Pyrrhotites, and porpyry associated with igneous rocks, iron sulfides, and magnetic minerals [2]. The "X" area is an area with regional lithology composed of volcanic deposits which generally have propylite, silicification, and argillic changes which are altered rocks [3]. So that the area can be used as a research location for mineral exploration using the magnetic method. The magnetic method itself is carried out to obtain rock susceptibility values which will later be used in interpretation to determine the type of rock that is below the surface [4].

II. Material and Methods

Earth's Magnetic Field

The earth's magnetic field has characteristics that can be seen from the physical parameters that can be measured, including the direction and intensity of the magnetism. The physical parameters are [4]:

a. Declination (D), which is the angle between magnetic north and the horizontal component calculated from north to east
b. Inclination(I), which is the angle between the total magnetic field and the horizontal plane which is calculated from the horizontal plane to the vertical plane downwards.
c. Horizontal Intensity (H), which is the magnitude of the total magnetic field in the horizontal plane.
d. The total magnetic field (F), which is the magnitude of the total magnetic field vector.

Sources of the earth's magnetic field are generally divided into three [5], namely the earth's main magnetic field (main field), external field (external field), and anomaly field (anomaly field). The value of the total earth's magnetic field for each location in different parts of the world is not the same. Each location that has different latitude and longitude coordinates will have different intensity values [6].

Each magnet has two different poles which when brought close will exert a force. The magnitude of the magnetic force between the two poles is directly proportional to the strength of each pole and inversely proportional to the square of the distance between the poles. The equation for the magnetic force is expressed in equation (1)

$$\vec{F}_m = \frac{\mu_0}{4\pi}\frac{p_1 p_2}{r^2}\hat{r} \qquad (1)$$

Where $\vec{F}_m$ is the force between the magnetic poles (N), r is the distance between the poles (m), p$p_1 p_2$ is the polar strength (Am) and μ_0 is the permeability in a vacuum of magnitude 4π x 10^{-7} (N/A^2).

Magnetic field strength

The magnetic force per unit pole strength is referred to as the measured magnetic field strength H . The magnetic field strength at the pole strength p1 is shown in equation (2).

$$\vec{H} = \frac{F_m}{p_2} = \frac{\mu_0 p_1}{4\pi r^2}\hat{r} \qquad (2)$$

A magnetic material placed in an external field H will produce a separate field that increases the total value of the material's magnetic field. Magnetic induction as the total field of the material is written in equation (3)

$$\vec{B} = \mu.\vec{H} \qquad (3)$$

where B is magnetic induction and is magnetic permeability. The value of rock susceptibility is greater if there are many minerals that are magnetic in the rock. Lithology (characteristics) and mineral content of rocks are factors that affect the susceptibility of a material [7].

Magnetic data processing

The data obtained are magnetic field data that has been corrected daily.

a. IGRF Correction

IGRF correction is carried out to eliminate the influence of the earth's main magnetic field. IGRF correction is done by subtracting the IGRF value from the total magnetic field value that has been daily corrected at each measurement point.

b. Contouring of the total magnetic field anomaly

The purpose of making a magnetic field anomaly contour map is to determine the distribution of magnetic field values at the research site. The input values are the coordinates of X (easting), Y (Northing), and Z as the total magnetic field anomaly value. Then the gridding process is carried out using the kriging method. This results in a map of the total magnetic field anomaly distribution.

c. Reduction to the poles

This transformation is often called Reduction to Pole (RTP). The input in carrying out this transformation is the inclination and declination values of each area to be brought to the magnetic field at the magnetic north pole. So that makes the inclination and declination values become 90o and 0o. This reduction aims to localize the magnetic field anomaly so that it is right above the body of the object causing the anomaly.

d. Upward continuation

This upward continuation is a filter to remove local magnetic effects originating from various scattered magnetic objects that are not related to the survey conducted. This process is carried out to reduce the effects of local anomalies originating from sources on the surface. The result of this upward continuation is a regional magnetic field anomaly map. The selection of appointments is made with consideration of the height of the research location so that it is not too high which can result in the loss of the research target. In the upward continuation, it can also be used to create a local magnetic field anomaly map. Making a local magnetic field anomaly map is done by entering an equation in the Oasis montaj software, namely in the form of reducing the distribution of the total magnetic field anomaly with the magnetic field anomaly that has been continuous upwards. The interpretation of the total magnetic field anomaly data in this study is divided into 2, namely qualitative and quantitative interpretations. Qualitative interpretation aims to determine the position of the object causing the anomaly based on the analysis results on the local magnetic field anomaly map. Quantitative interpretation is done by making a model from the anomaly map. On the map, an incision is made that passes through pairs of positive and negative anomalies. The choice of incision position is based on a qualitative interpretation.

III. Result and Discussion

The result of the magnetic method is in the form of anomalous values of the magnetic field from rocks below the surface. The value of the magnetic field anomaly is generated from the value of the total magnetic field at the measurement point which has been made several corrections beforehand. Corrections are made in the form of daily variation correction to eliminate the influence of the external magnetic field and IGRF (International Geomagnetic Reference Field) correction to eliminate the influence of the main magnetic field value. The magnetic field anomaly map at the measurement point can be seen in Fig 1.

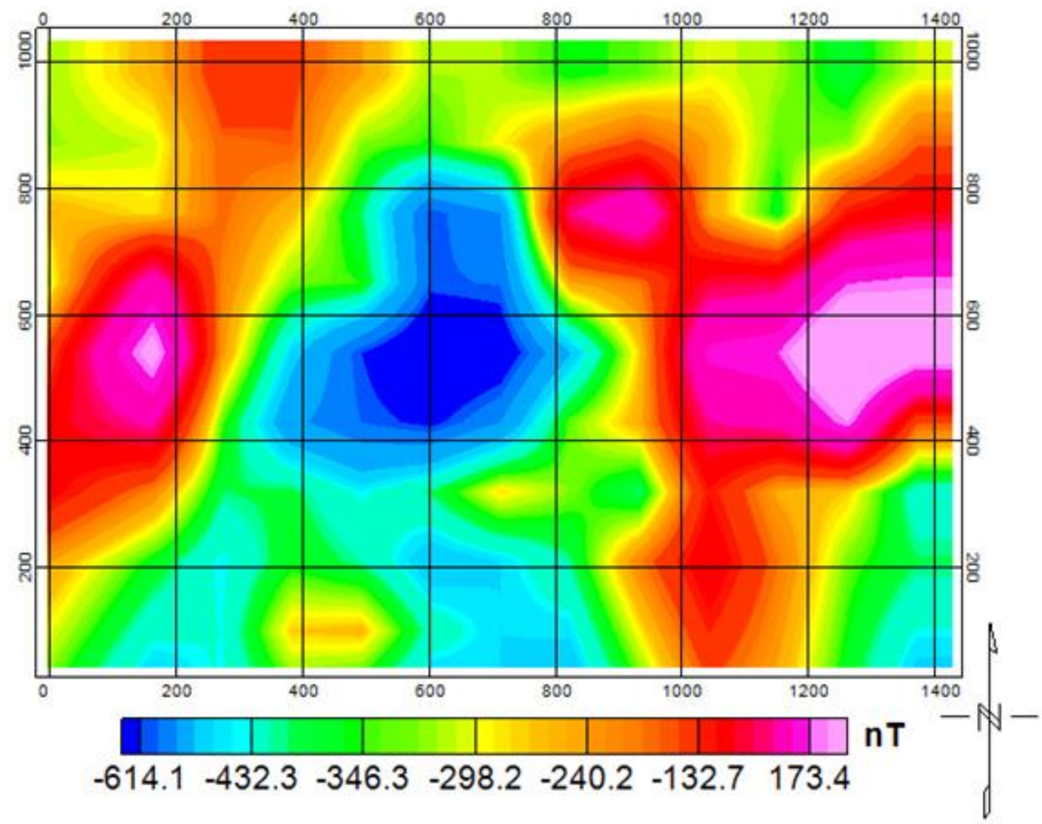

Figure 1. Contour map of total magnetic field anomaly

The pattern on the contour of the total magnetic field anomaly consists of positive closure with a maximum value of 373.7 nT and negative closure with a minimum value of -1513.3 nT which indicates that the magnetic field anomaly is a dipole. The magnetic field anomaly is the result of a combination of the raman magnetic field and the induced magnetic field.

The total magnetic field anomaly data is then filtered in the form of reduction to the poles. Reduction to the poles is a magnetic data processing filter to eliminate the influence of two poles due to inclination and declination angles. At this stage, it is done by making the object's inclination angle to 90o and its declination 0o by entering the inclination and declination values of the area as initial input. The inclination and declination values of the area are -24.6402o and 0.0374o. The result of the reduction to the poles shows an anomaly of the magnetic field that becomes one pole (monopole). It can be seen that the anomalous contour has become a monopole. For the prospect area for gold minerals, namely on contours with high magnetic field anomaly values. The low value of the magnetic field anomaly can be interpreted as a decrease in the magnetic value which may be caused by a fault.

The total magnetic field anomaly data after being reduced to the poles is then filtered in the form of an upward continuation (Upward Continuation). Upward continuity is carried out to change the potential field data measured at the surface level to data that seems to be measured at a higher surface level. Upward continuation aims to help in separating local anomalies and regional anomalies. In this research data is refined by lifting upwards as high as 1100 m. Observation data with upward as high as 1100 m can be seen in Fig 2

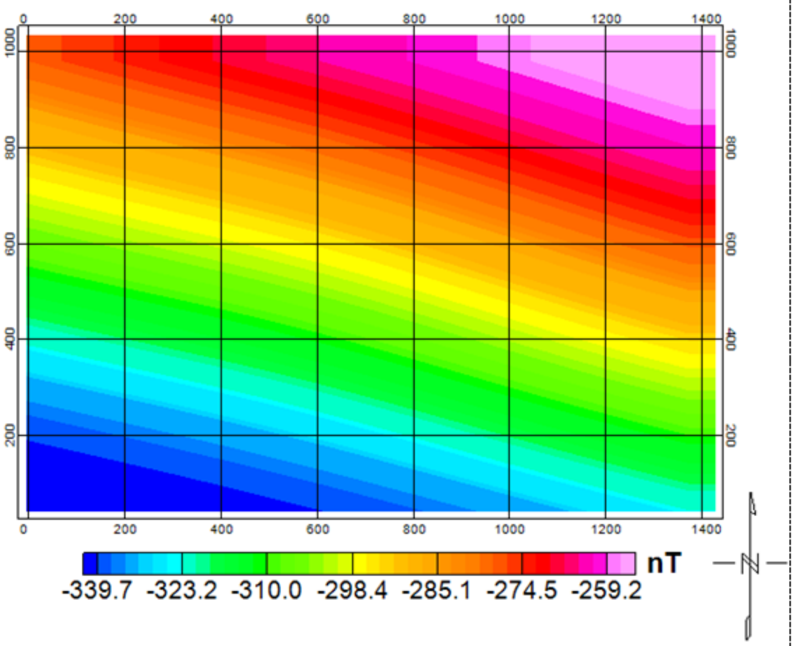

Figure 2. Contour map of total magnetic field anomaly after upward 1100 m

Uplift as high as 1100 m was chosen because this value is good enough to separate local anomalies from regional anomalies. From the upward continuation can be used in the separation of local and regional anomalies. The results of the local anomaly can be seen in Fig 3. In this study, the map used is a local magnetic field anomaly map. It can be seen in Figures 4.1 and 4.4 that the total magnetic field anomaly is not much different or only changes slightly. This confirms that the value of the local magnetic field anomaly has a large influence. So in this study, a local magnetic field anomaly map was chosen to achieve the survey target, namely the distribution of minerals. This is done to get a good interpretation.

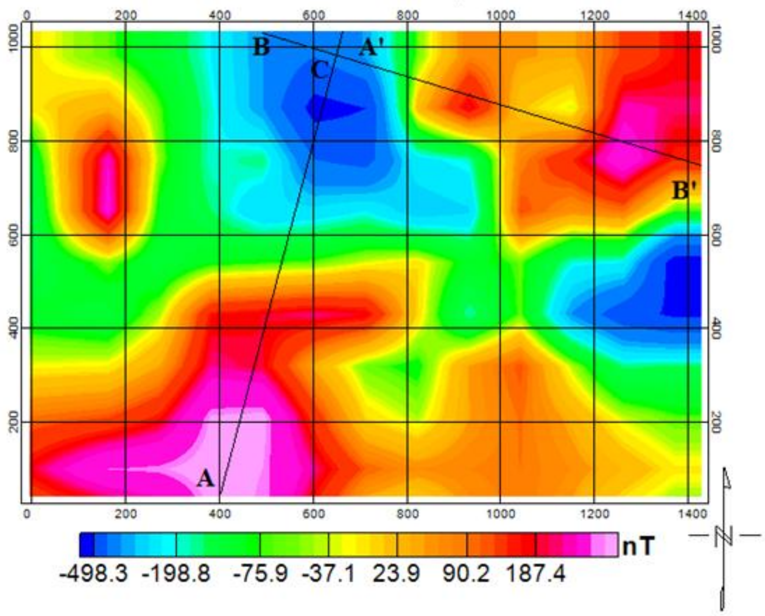

Figure 3. Contour map of local total magnetic field anomaly

The results of the modeling of the A-A' incision in the area consist of 4 types of rock with different susceptibility values. The first rock was identified as andesite rock which has a high susceptibility value. This formation is modeled in red which has a susceptibility value of 0.016 emu with a depth of 293 m to 600 m from the surface. The second rock has a susceptibility value of 0.007 emu with an average depth of 67 m to 360 m. This formation is modeled in green which is identified as andesitic tuff rock. The third rock is lapilli tuff. This formation is modeled with turquoise green which has a susceptibility value of 0.005 emu which is up to a depth of about 388 m. The fourth rock is breccia which is identified as the source rock. This formation is modeled in blue which has a susceptibility value of 0.001 emu with a depth of 61 m to 600 m. From the modeling results, the error value is 7.593.

The model shows that there is a rock structure in the form of a normal fault. Judging from the geological map, breccia rock is the parent rock which is then intruded by magma intrusion which then becomes andesite rock. The void between the intrusive rock and the breccia rock is then filled with andesitic tuff rock. Andesitic tuff rock fractured and subsided. The subsidence of the rock layer resulted in a void in the layer above which was then filled by volcanic material and settled into a new layer of tuff lapilli. Figure 4 shows the subsurface structure of the A-A' incision in 3D. It can be seen that there is a fault and it is filled with new sedimentary material. This fault in geology is called a normal fault. This is in accordance with the results of 2D modeling of the A-A' incision that there is a fault structure where the fault is a normal-fault which is then filled with new material deposits.

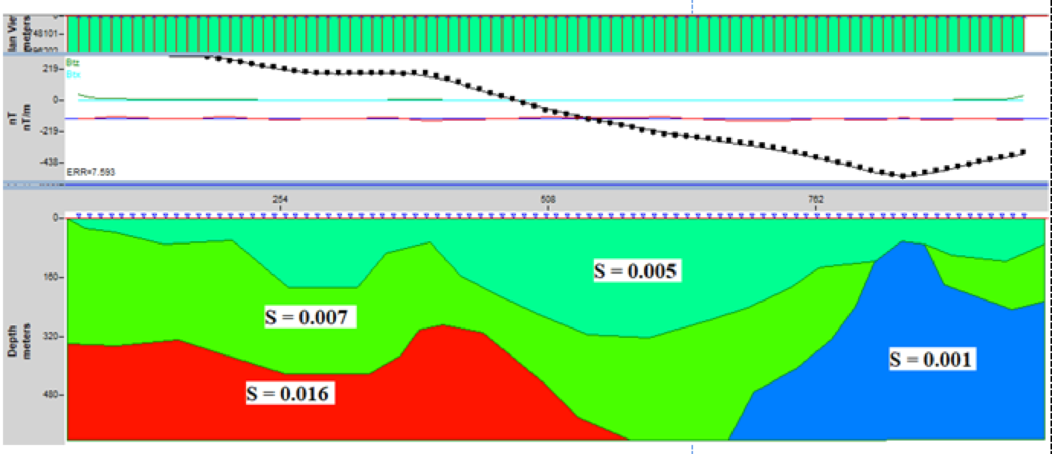

Figure 4. The results of the A-A' 2D incision modeling

In the results of the modeling carried out on the B-B' incision shown in Figure 7, the area consists of 3 types of rock, namely tuff, breccia, and andesite. In this modeling, tuff rocks are divided into 2, namely andesitic tuff and lapilli tuff. The first rock identified as breccia rock which has a low susceptibility value from the surrounding rock.

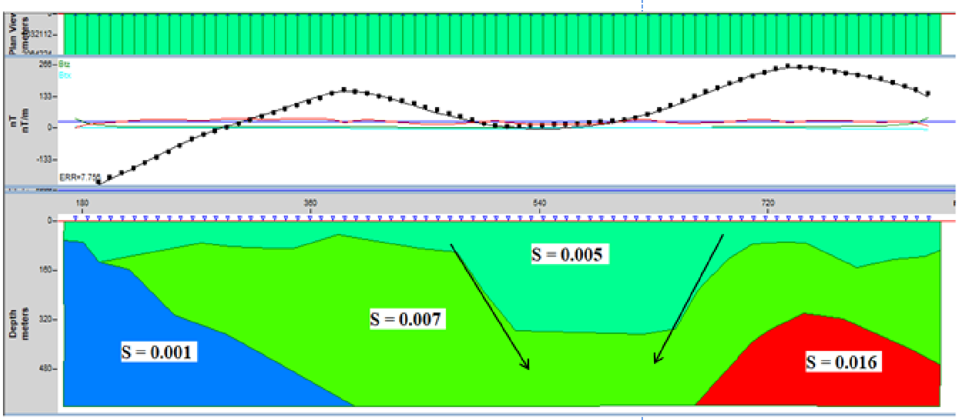

Figure 5. The results of the B-B' 2D incision modeling

This formation is modeled in blue colour which has a susceptibility value of 0.001 emu with a depth of 65 m to 600 m from the surface. The second rock has a susceptibility value of 0.007 emu at a depth of 71 m to 600 m. This formation is modeled in green which is identified as andesitic tuff rock. The third rock has a susceptibility value of 0.016 emu at a depth of 304 m to 600 m. This formation is an andesite rock modeled in red. The fourth rock has a susceptibility value of 0.005 emu to a depth of 360 m. This formation is identified as lapilli tuff rock which is modeled in turquoise green. From the modeling results, the error value is 7,756. As in the A-A' incision, the subsurface structure of the B-B' incision in Figure 8 shows a fault. Because there is an opposing force causing the space to crack and fall and cause a large enough fracture so that new sedimentary material can fill the space. The fault is a geological structure in the form of a down fault. This is in accordance with the results of the 2D modeling of the B-B' incision shown in Figure 7 that there is a fault structure where the fault is a normal fault.

IV. Conclusion

Based on the interpretation results obtained tuff rocks with a susceptibility value of 0.005 emu to 0.007 emu in the form of veins that appear on the surface and in areas with shallow depths to a depth of 388 m. There is also a geological structure in the form of faults below the surface. We interpreted the fault as a normal fault. The rock formations from the 2D modeling results are lapilli tuff, breccia, andesite, and andesitic tuff rocks with susceptibility values of 0.005 emu, 0.001 emu, 0.016 emu, and 0.007 emu, respectively.

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