Mapping of gold mineralization using 3D inversion magnetic data at Zone X, West Java

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Abstract. Gold mineralization occurs when the hydrothermal fluid rise beneath the earth's surface. Tectonic activity causes gold mineralization in several depositional environments, one of which is a low epithermal sulfide deposite. This type of deposite is characterized by low temperatures and controlled by many geological structures. The discovery of veins in geological mapping in Zone X needs to be supported by geophysical exploration to identify the distribution of gold mineralized zones. This study aims to identify zones of gold mineralization based on magnetic data. From the results of the study obtained the susceptibility parameters of the 3D inversion process of magnetic data. The results are verified by map of gravity anomalies and geological structures. So that there are 2 interesting blocks which are interpreted as zones of gold mineralization in the southeast-northwest orientation and the depth of the dominant magnetic body at 900 masl to 20 masl.

1. Introduction

The Zone X area is located in West Java, Indonesia. The Zone X is situated as an area with high topography in the former X volcano area. This former volcano indicates that there used to be a magmatism process which is closely related to hydrothermal fluid [1]. In addition to the existing manifestations found the type of mineralization in Zone X is low epithermal sulfide [2].

Zone X area has a distribution of lithology in the form of andesite, tuff, lapilli tuff, tuff breccia and andesite breccia. In the Figure 1, there is a dextral strike slip fault that has a southeast-northwest orientation where this fault is interpreted as the first period [3]. In the second period [3] after the explosive X volcano caused normal fault complexes that form a circular caldera structure. The presence of a normal fault complex is indicated as a mineralization line controller. Minor faults to this pull become open structures that are very suitable as mineralized pathways [1].

Based on the results of geological mapping, vein outcrops have been discovered. Difficult to find correlations between outcrops, geophysical exploration is carried out, one of which is the measurement of gravity method [4]. The results still have a ambiguity because not all zones of gold mineralization have a high anomaly gravity based on these problems, it is necessary to measure other geophysical methods, one of which is the geomagnetic method.
Figure 1. Geology Map Zone X

Magnetic method is a method that measures the magnetic properties of rocks below the surface. This method is often used to identify structures associated with the distribution of gold mineralization [5]. The loss or disruption of the magnetic properties of rocks can be caused by the presence of high temperatures and pressures, the process is called hydrothermal alteration. The gold mineralization process is usually found in zones that have low magnetic susceptibility value [6]. Therefore, 3D inversion modeling is carried out to determine the distribution of zones that are thought to have indications of gold mineralization. In addition, to strengthen these interpretations, a comprehensive modeling of magnetic 3D inversion results with maps of gravity anomalies and geological structures.

2. Method
The acquisition of the magnetic data is done by the Antam Geomin unit with 8379 measurement points, 11 trajectories, distance between measuring points 2-5 meters while the distance between tracks varied from 200 m to 1 km and the measurement area covered was about 25 km².

Processing the magnetic data produces anomaly total magnetic intensity. The reader of this magnetic intensity anomaly map still has a two-pole effect. Then the reduce to pole (RTP) process is carried out to make existing magnetic anomaly data be monopole (one pole). The inversion modeling process is then carried out. In principle this modeling produces susceptibility parameters that are distributed below the surface. Each magnetic anomaly data obtained in the measurement will be set in the depth of an orthogonal cell in the form of a 3D mesh. Magnetic anomalies will have a relationship with subsurface susceptibility in a linear manner. The following equation can be written as

\[ d = Gm \]

where \( d \) is magnetic anomaly (nT) data, \( m \) is the model parameter or susceptibility value in cell. \( G_{INs} \) is the kernel matrix that maps the source of the anomaly to the observation data with \( N \) being the number of data and \( M \) is the number of model parameters [7].
3. Results and Discussion
On the RTP anomaly map, the very low magnetic anomaly (-100 nT to -400 nT) is distributed in the northwestern part of the study area. The anomaly value indicates an altered rock region. In the low magnetic anomaly areas (-50 nT to 0 nT) in Figure 2, the geological data confirmed the presence of tuff rocks as a product of the X volcanic eruption. The tuff rock was deposited as primary sediment and it seems has been partially altered, causing the value of the magnetic anomaly to be low. The physical changes due to precipitation are primarily indicated to affect the intensity of the magnetic anomaly associated with the Depositional Remanent Magnetization (DRM) process [8]. In the southeast of Zone X there is a relatively high value of intensity magnetic anomaly (50 nT to 300 nT). The high anomaly may caused by rocks containing mineral magnetite. The high anomaly rocks may interpreted as andesite breccia rocks.

![Figure 2. Reduced to pole map Zone X](image)

In the inversion results as show in Figure 3, there is suspected mineralized area that has a low susceptibility value due to the hydrothermal effect of demagnetization. In this area the hydrothermal fluid most probably mixing with meteoric water so that the pH concentration goes neutral and causes damage to the magnetite mineral content in the rocks. The distribution of the mineralized zone follows a strike slip fault pattern that has a southeast-northwest orientation and is controlled by the normal fault structure of the former volcanic caldera X, this results in the pulling force on the normal fault plane and small fracture openings which have a slope. [9]. The depth distribution of the mineralization zone ranges from 900 meters above sea level to -570 meters above sea level. However the dominant area of low susceptibility anomalies are distributed at depths between 900 meters above sea level.

The inversion modeling of 3D magnetic is supported by residual gravity anomaly map of Hafidz [4]. The distribution of gravity anomaly values ranges from -2 to above 7 mgal. The high-colored anomaly is in the middle that extends from southeast to northwest. The high-gravity anomalies, geologically are dominated by tuff, lapilly tuff and tuff breccias. Both high gravity anomaly area (the west central and the middle east part) are considered as an interesting area. The lithology found in this area is lapilly tuff/tuff rock. This rock usually tends to have a small gravity anomaly value, but at this location the distributed gravity value has a positive and high gravity anomaly value. It indicates that in lapilly tuff/tuff rocks there is gold mineralization which makes the gravity anomaly value positive and high. The presence of gold mineralization is also
strengthened by suspected the presence of distributed geological structures in the region. Both figure 3 and figure 4 show the low susceptibility and high gravity anomaly are strongly distributed around the structures. The areas are believed as gold mineralization zones.

Figure 3. Map of 3D Inversion low susceptibility zone

Figure 4. Residual anomaly gravity map [4]

Further the integrated model of 3D magnetic inversion and gravity anomaly map (see Figure 5) shows some distribution of low magnetic susceptibility values just above the two residual gravity
anomaly regions that have high values (circled by white). This is also reinforced by the presence of a strike slip fault structure in where this fracture is thought to be an opening zone that traps hydrothermal fluid so that the mineralization process is believed occurs in the area of block A and block B. The region are in the tuff / lapilly tuff, It is supported by Milesi experience [2] that state the formation of the gold mineralized zone is in the dominance of lapilly tuff rocks.

Figure 5. Map of Integration model

4. Conclusion
From the results, it is indicated there are 2 interesting block areas, namely block A and block B. There are have orientation from southeast to northwest. The litology of regions are tuff/tuff lapili and andesite breccia. In block A and block B areas, the high gravity anomaly values are 3-7 mGal and the magnetic susceptibility value is low (-0.063 to -0.013 cgs) with the dominant magnetic body depth around 900 to 20 masl, accompanied by the presence of a caldera and a strike slip fault dextral so that the veins of open mineralization develop that are parallel to the control structure.

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