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Geophysical Ground Magnetic Investigations of Lady A Claims in Concession, Zimbabwe

Bernard Siachingoma[1], RenisiaTipedze[2]

[1]Geophysics Lecturer, Physics Department, Midlands State University, P/Bag 9055 Gweru, Zimbabwe

[2]Undergraduate Student, Physics Department, Midlands State University, P/Bag 9055 Gweru, Zimbabwe

Abstract: ***A geophysical subroutine using magnetic method was conducted on lady A claims in the concession area 75 km NNW of Harare, Zimbabwe. The survey area lies in the mineral rich greenstone belt. The rocks in the study area include mafic to felsic volcanics with occasional sediments and ironstone intercalations. The gold mineralization is associated with quartz reefs hosted within metabasalts. The reefs are concordant to the parallel shear zones in banded ironstones. The ground magnetics survey done revealed interesting structures with potential to host mineralization. Induced polarization was recommended as a follow method to clearly delineate the observed structures.***

Keywords: magnetic method, greenstone belt, gold mineralization, delineate

1. Introduction

The magnetic method is the oldest exploration technique based on measuring the Earth's magnetic field and is the primary tool in the search for minerals which boomed significantly after the advent of better techniques in World War II. The magnetic field of the Earth is a vector measured by a magnetometer (Lowrie, 2007). Magnetic measurements have long been used to map regional geological structures and to carry out mineral exploration (Reford, 1980). A ground magnetic survey was done with the goal of generating structural maps which would aid in highlighting potentially favourable areas for gold mineralization within the host rocks. The generated magnetic anomalies were used to determine outcrop positions and structures. Many rocks in the earth's crust exhibit magnetic properties due to a combination of present day geomagnetic field and remnant magnetisation acquired in the geologic past.

Magnetization of any structure is due to induction in the geomagnetic field and permanent magnetization (remanent) (Parasnis 1972). Mapping the patterns of magnetic anomalies attributable to rock magnetism has been proven to be effective in mapping lineaments that reflect fracturing, faulting, folding and shearing which are potential conduits for gold mineralization. Structural geometries such as disconformities may also be mapped using litho-magnetic magnetic variations. All geological structures, rocks, minerals, ore deposits and engineering geological structures have magnetic properties that differ by orders of magnitude rather than percentages (Milsom 2003).

Induced Polarization survey was designed as a follow up to assess the existence of disseminated sulphides associated with structures identified by magnetic surveys. Non-uniqueness in the interpretation of anomalies justifies the use of other methods and cross check interpretations. Identifying such sulphides is a major pointer for gold occurrence. Sulphide minerals such as pyrite, chalcopyrite etc. are usually associated with and therefore pathfinders to economic gold occurrence.

Magnetic rocks contain various combinations of induced and remnant magnetizations that perturb the Earth's primary field (Reynolds, 1990). This report is based on the conduct, analysis and interpretation of the magnetic survey data, field observations and historical data from the Zimbabwe Geological Survey publications. Processed magnetic image maps define region of terrain that may contain magnetic minerals. Careful examination of the data gives important clues to what is underground. Magnetic surveying is a rapid and cost effective technique and represents one of the most widely used geophysical methods in terms of line length surveyed (Kearey*et al.* 2002)

2. Theory

The aim of any magnetic survey is to investigate and describe subsurface geology on the basis of anomalies in the Earth's magnetic field resulting from the magnetic properties of the underlying rocks (Lorie, 2007). The main component of the measured magnetic field originates from the magnetic dynamo in the earth's outer core (Campbell, 1997). All magnetic anomalies caused by rocks are superposed on this geomagnetic field. The magnetic anomaly caused by a small isolated pole of strength m, at a radial distance r from observation point

$$\Delta \boldsymbol{B} = \frac{\boldsymbol{Cm}}{r^2} \qquad (2.1)$$

$\Delta \boldsymbol{B}$is the change in strength of the total field vector **B** and$\boldsymbol{c} = \frac{\boldsymbol{\mu_0}}{\boldsymbol{4\pi}}$ (Kearey*et al.* 2002). Themagnetic content and hence susceptibility of rocks is extremely variable and there can be considerable overlap between different lithologies (Kearey*et al.* 2002). The magnetic anomalies caused by rocks are localised effects superposed on the magnetic field of the Earth and the magnetometer measures this total field. A magnetometer locates ferrous metals by measuring local perturbations in the strength of the Earth's magnetic field (Benson, 1984). The main application is in detailed survey for minerals or geochemical reconnaissance in base-metals search (Telford et al. 1990).

3. Project Area and Location

Lady A claims are located Concession 75 km NNW Harare whose position in relation to regional geology is shown in figure 1. They are within Rhambahoobe farmland to the west of the Mazoe-Mvurwi road. The size of the surveyed block was 10 ha, a detailed outline of which is shown in Figure 2. The property boundaries were located with a hand held GPS and UTM Zone 36 in conjunction with the map showing an outline the blocks from the ministry of mines. The beacons are erected on this property satisfying a requirement in the mines and minerals act. The terrain in which the claims lie is uneven with very small ridges and hills composed of fairly resistant rock sporadically defining NNE-SSW trend. Outcrops are very abundant where low hills and ridges have preserved them enabling field observations to be made. Old workings also helped expose some outcrops for better observation. Weathering is fairly thick in the area and the soil colour is predominantly red brown with a clay texture.

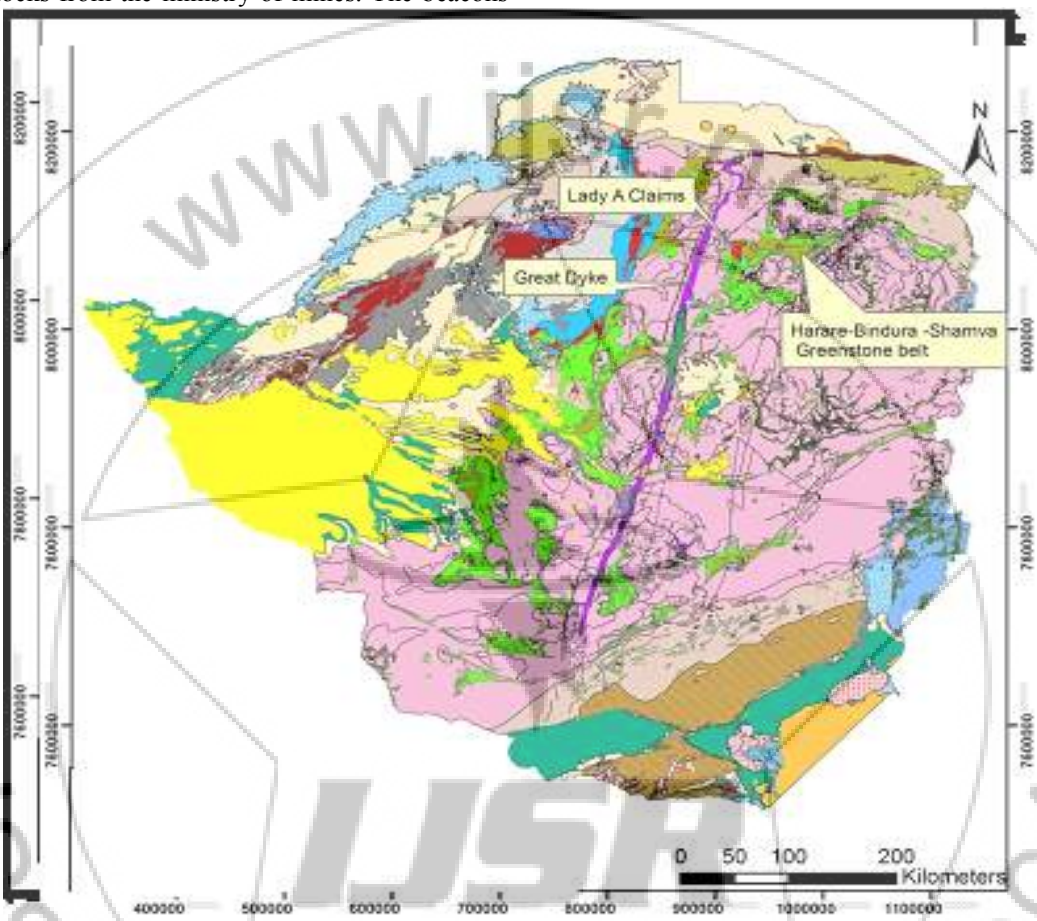

Figure 1: Geological Map of Zimbabwe showing the location of Lady A Gold Mine Claims in relation to the regional geology

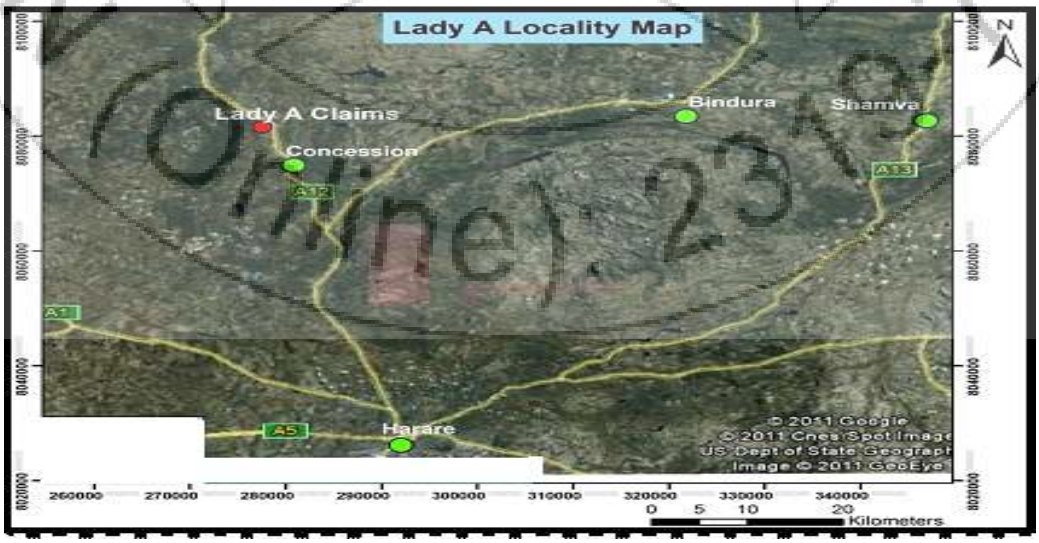

Figure 2: Google image showing the location of Lady A Gold Claims with respect to Harare, Concession, Bindura and Shamva

No official documented records exist but based on field observations previous workings suggest some exploration activities as there were small scale mining activities along the reef and its vicinity.

4. Survey Methods

Two blocks were surveyed by a 1 nT proton magnetometer as a roving field machine. The two blocks were 500 m x 200 m. The sensor clearance was 2.5 m. The magnetometer sensitivity was +/- 0.1nT. The survey line interval was 50m and along line sampling interval was 10 m.

5. Data Processing and Presentation

Data reduction was carried out using Gemlink W 3.0 software and presented Excel*.xls for geosoft grid files. Interpretive maps were generated in order to facilitate the interpretative exercise aimed at improving the spatial mapping resolution of the litho-magnetic units and enhancing subtle features of limited amplitude and continuity. Transforms in the frequency and space domain were effected using Geosoft and Map Info packages. The reduction to the pole transforms generated total field data whose magnetic field anomaly was commensurate with a 90^0 inclination of the earth's magnetic field for induced magnetisation of the prospective area. The effect was simply the magnetic map and rendered anomalies independent of strike and generated symmetrical anomalies over steeply dipping dyke like magnetic sources. Asymmetric anomalies reflect dipping sources or those with a strong remnant magnetisation.

Gradient data emphasise shallow response at the expense of broader regional features and allow for the recognition of low amplitude, shot wavelength magnetic anomalies (dykes) in areas of significant magnetic relief. Vertical gradients were less complex over steeply dipping sources. Second derivative further boosted the response of shallow targets but higher noise levels were experienced. Over isolated bodies, second derivative data has advantage that zero level contours approximate contacts of magnetic body. The magnetic image processed data showed some relief shading highlights short wavelengths, low amplitude anomalies at shallow depths in total field and related data sets. Steep features generated sharp intense shadows. Where azimuth is at large angle to the strike (perpendicular) the process allowed for the visual confirmation of strike continuity along sectors where anomalies were poorly developed. Because of the erratic and complex nature of the magnetic maps, interpretation is often only qualitative (Telford et al. 1990).

6. Results and Discussion

The images in figure 3 to figure 5 show the results of the magnetic survey in the Lady A Claims area. As can be seen from the images, high magnetic signatures were noted in most of the area in the south east and some sections in the north-west. This high magnetic zone also shows hints of NW-SE trending structures, and they clearly demarcate the shear zone along major streams (possibly defining faults) as noted during the geological mapping. The orientation of the shear zone as given by the magnetic survey results clearly coincided with the position obtained from mapping. The high magnetic signatures in the east appeared open ended, hence there is a possibility of another potential shear zone or potential mineralisation further east, but this could not be confirmed by the geological mapping due to lack of outcrop, and since that portion lies outside Lady A boundaries.

The blue magnetic signature in the west and central part of the image is due to non-sampling due to inaccessibility since certificates for the block were not yet out at the time of the survey, hence slight ownership disputes with the neighbours.

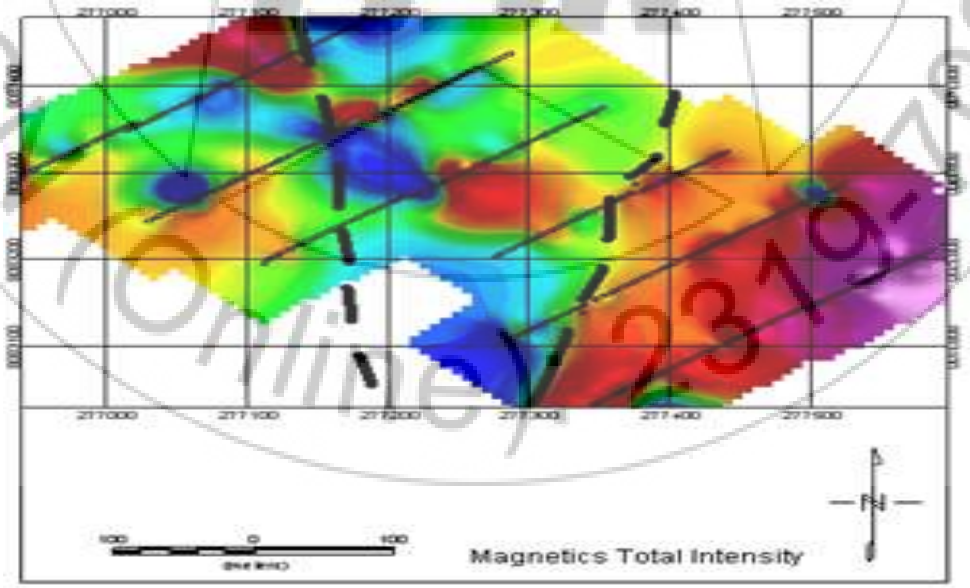

Figure 3: Total Magnetic Intensity Results for Lady A Mine Claims area.

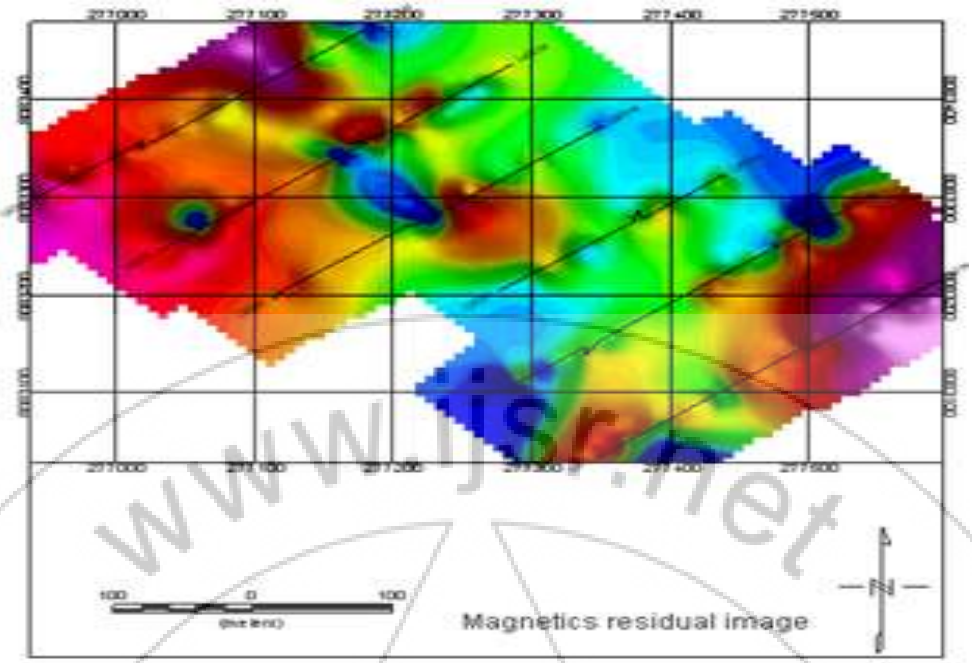

Figure 4: The magnetic residual image

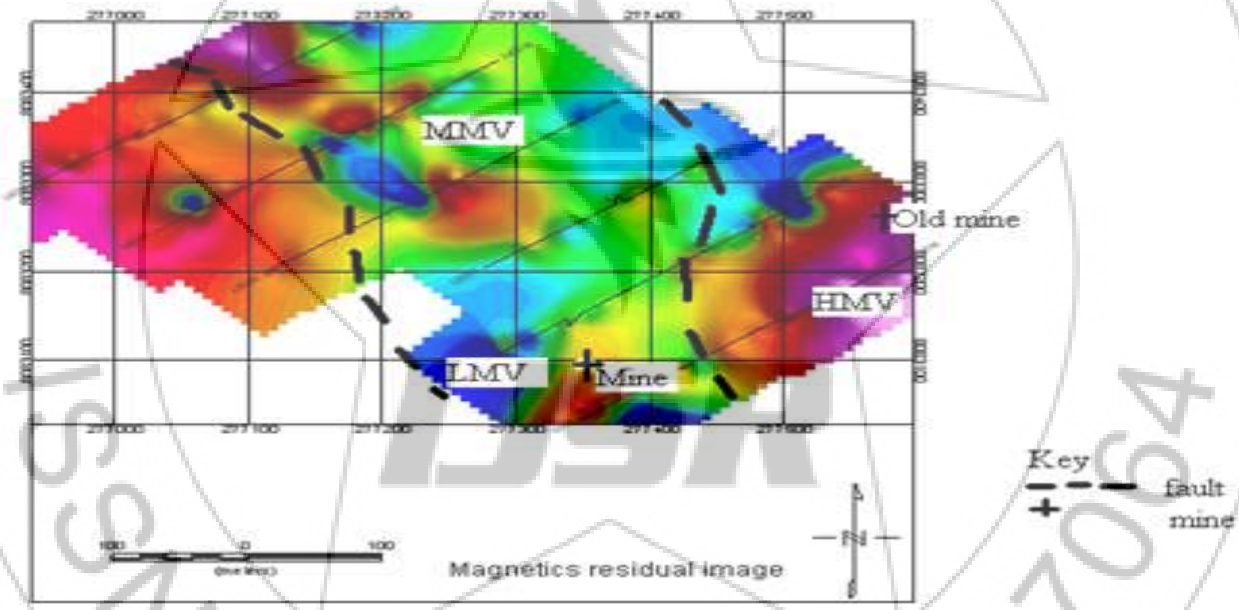

Figure 5: The interpreted magnetic residual image

7. Conclusions

The ore body in the area is hosted in a sheared, sulphidated and highly oxidised meta-basalt. Although the two of the three exploration shafts sunk had not yet intersected the reef at about 16 m, the third one had already intersected a WNW trending reef that was characterized by oxidised sulphides and minor vein quartz material. Even so, large proportions of disseminated sulphides (mainly pyrite) were clearly visible in the host rock. It was therefore anticipated that better mineralisation would be encountered in these shafts upon reaching optimal depths of between 25-30 m. The results showed good prospects for mineralisation. In the next article we shall report our work using the induced polarisation method on the same site.

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