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The Magnetic Signature of Gold Bearing Rocks at Mphoengs

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Abstract: ***Geophysics can make significant contribution to the life of mankind by skilfully helping in the precise location of valuable concealed ore deposits of economic value. The aim of this study was to conduct a geophysical survey using ground magnetics on NMPL north and south base metal blocks to detect disseminated sulphides which are associated with gold mineralisation located in Mphoengs, Bulilimamangwe District of Zimbabwe. More specifically it sought to generate anomaly maps of the study area with the ultimate aim of establishing beyond doubt regions with greater concentration of valuable gold deposits. A series of measurements were done and results presented as anomaly maps. The project is located within a narrow corridor of variably altered talcose horn blend-chlorite schist and serpentinites. This is a highly mineralized gold zone that has seen significant gold production in the past and shows potential for discovery of major gold resources in the future. The study area is located within a geologic setting considered highly prospective for the presence of a low tonnage high grade, bulk mineable gold deposit. The results really show the applicability of Physics to providing practical solutions to real problems. The established anomaly maps are usable by the project client to plan and zoom in on the most profitable regions of the surveyed area.***

Keywords: Geophysics, magnetics, disseminated sulphides, gold mineralisation, potential, mineable deposit, anomaly maps

1. Introduction

Over the years, the need to precisely locate buried ore bodies has intensified. The need for larger quantities of usable mineral has boomed as technology and human population soared to higher levels triggering the development of advanced methods for exploration. Magnetics has emerged as one of the methods used successfully to precisely locate the position of valuable deposits of economic value making it possible to contribute significantly to the advancement of mankind. The aim of the magnetic survey was to investigate subsurface geology on the basis of anomalies in the Earth's magnetic field resulting from the magnetic properties of the underlying rocks. The concept of magnetics has long been important and continues to be improving to date. Ground magnetic survey is a type of magnetic survey that is performed on the ground or on land. Ground magnetic surveys are performed over small areas, with station spacing of 10 -100m (Kearey *et al.* 2002). Magnetic method is a common geophysical method used today in geology and engineering geology in locating buried hills, geological faults, intrusions of igneous rock, salt domes associated with oil fields, concealed meteorites and buried magnetic objects such as pipe-lines, etc (Parasnis 1979). 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). Although most rock-forming minerals are effectively non-magnetic, certain rock types contain sufficient magnetic minerals to produce significant magnetic anomalies. Similarly, man-made ferrous objects also generate magnetic anomalies. Magnetic surveying thus has a broad range of applications, from small scale engineering or archaeological surveys to detect buried metallic objects, to large-scale surveys carried out to investigate regional geological structure. Magnetic surveys can be performed on land, at sea and in the air (Lowrie, 2007). Consequently, the technique is widely employed, and the speed of operation of airborne surveys makes the method very attractive in the search for those types of ore deposit that contain magnetic minerals.

Magnetic anomalies caused by rocks are localized effects superimposed on the normal magnetic field of the Earth (geomagnetic field). All magnetic anomalies caused by rocks are superimposed on the geomagnetic field in the same way that gravity anomalies are superimposed on the Earth's gravitational field. Magnetic rocks contain various combinations of induced and remnant magnetizations that perturb the Earth's primary field (Reynolds, 1990). The magnetization intensity and intensity in which the Earth's magnetic field is changed, depends on the magnetic susceptibility of the ore, mineral or rock under the investigation. Magnetic susceptibility is the degree to which rocks, minerals, ores or a certain body is magnetized (Clayton *et al.*1995). The magnetic case is more complex, however, as the geomagnetic field varies not only in amplitude, but also in direction, whereas the gravitational field is everywhere, by definition, vertical. Consequently, knowledge of the behavior of the geomagnetic field is necessary both in the reduction of magnetic data to a suitable datum and in the interpretation of the resulting anomalies. Remanence magnetism is the residual magnetism or natural remanence magnetization which forms part of net magnetization in an object (Telford *et al.* 1990). 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). That is why it was employed in this study.

Magnetic surveying consists of measuring the terrestrial magnetic fields at predetermined points, correcting the measurements for known changes and comparing the

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resultant value of the field with the expected value at each measurement station. The expected value of the field at any place is taken to be that of the International Geomagnetic Reference Field (IGRF). The difference between the observed and expected values is the magnetic anomaly (Lowrie, 2011). This is the parameter of interest in any magnetic survey. Geological surveying was the first for the whole area in general as well as particularly at exposed outcrops followed by the magnetic surveying which is reported below.

2. Study Area

The Project Area is located 210 km south of the city of Bulawayo in Bulilima Mangwe District. The claims within the northern block of the project area are centred at 590,913.49 (UTMARC1950E) and 7,653,021.07 (UTMARC1950N) and cover a combined total area of 205.7 Ha. All claims boundaries on the northern block have been marked by fixed beacons.

Present access to the claims is via a provincial tarred highway that heads south from Bulawayo to the town of Plumtree. A district tarred road heads off from Plumtree town towards Mphoengs Police Station for 63 km after which there is a well maintained gravel road for 36 km up to Mphoengs Police Station. The project area is located 3.8 km directly southeast of Mphoengs Police Station. Access to the claim is possible throughout the year, save for the last 6 km of gravel road from Brunapeg turn-off to the project area, which is poorly maintained and becomes slippery and rugged during the wet season.

Topography in the area shows moderate relief, averaging 949 m above mean sea level. The terrain is characterised by low-lying hills which fall gently towards Ingwizi River which straddles the southern boundary of the northern block. Waterways include numerous streams that feed into Ingwizi River to the south. The drainage system describes a dendritic pattern, with Ingwizi River draining southward to a confluence with Ramaquabane River approximately 5 km south of the northern block. Soil cover is generally shallow with relatively deeper profiles in the valleys.

There is no source of electrical power from the national grid, close to the project area. Currently the project relies on a 250 KvA generator for electricity supply. In the future, the project will have to draw electricity off a Zimbabwe Electricity Supply Authority (ZESA) power line currently being installed at Mphoengs Police Station. Potable and industrial water is drawn from a borehole that has been drilled and equipped on site. In general, the current infrastructure on the project is adequate and can sustain a constant move into production if with power, communications, water supply, housing and workshops all at functional levels.

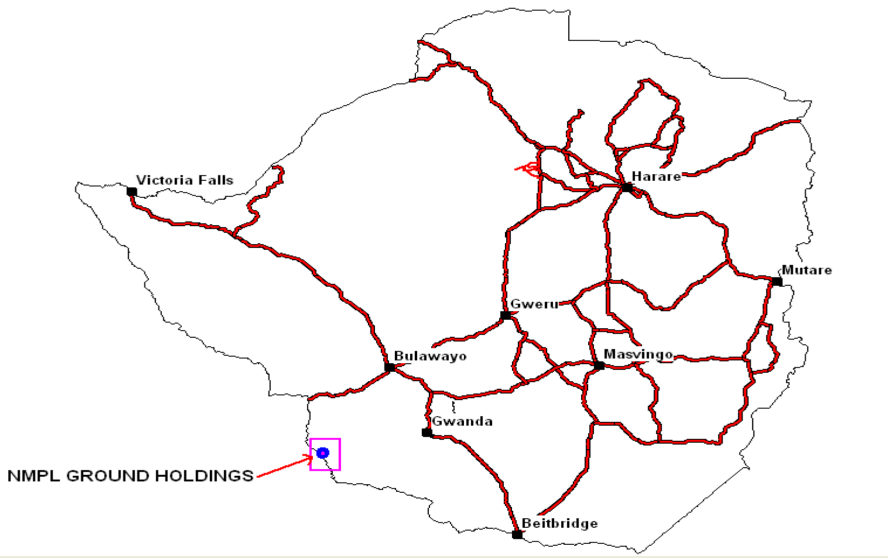

Figure 2.1: Map of Zimbabwe showing the location of NMPL ground holding

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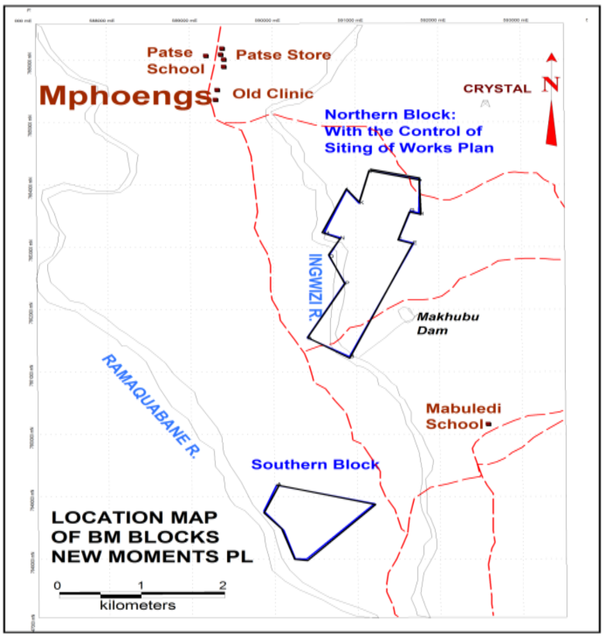

Figure 2.2: Location map of BM Blocks,Mphoengs.

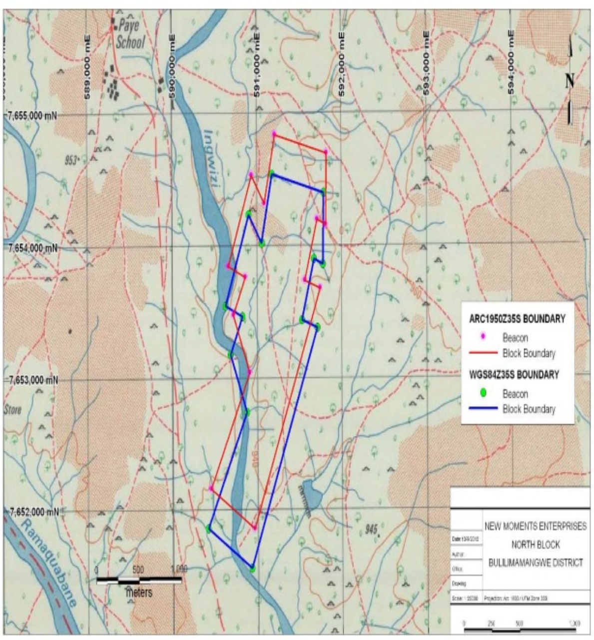

Figure 2.3: Map of NMPL northern block.

3. Methodology

Since 19th century different field magnetic instruments which are capable to measure the geomagnetic elements have been designed (Kearey *et al.* 2002). In this study, a proton precession magnetometer was used. This instrument gives absolute measurements of the net magnetic field from any engineering or geological feature accurate to 0.1 nT (nanoTesla) (Kearey *et al.* 2002). Problems like incorrect calibration are not experienced and inherently it is drift free (Griffiths and King 1981) and this instrument requires no leveling (Parasnis 1972). The main disadvantage of the instrument is the measurement of only the total field (Telford et al. 1990).

During the survey, all the key aspects of doing a magnetic survey were followed. Sources of artificial noise were eliminated, diurnal corrections are essential in most field work, unless only gradient data are to be used. If only a single instrument is available, corrections have to rely on repeated visits to a base or sub-base, ideally at intervals of less than one hour. A more complete diurnal curve can be constructed if a second, fixed, magnetometer is used to obtain readings at 3 to 5 minute intervals. At the start of each survey day the diurnal magnetometer must be set up. The first reading of the field magnetometer should be at a base or sub-base, and should be made at the same time as a reading is being made, either automatically or manually, at the base. This does not necessarily require the two instruments to be adjacent. At each station the location, time and reading must be recorded, as well as any relevant topographic or geological information and details of any visible or suspected magnetic sources. At the end of the day, a final reading should be made at the base first occupied. This should again be timed to coincide with a reading of the diurnal magnetometer.

4. 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.

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. Because of the erratic and complex nature of the magnetic maps, interpretation is often only qualitative (Telford et al. 1990).

5. Results and Discussion

The data obtained was processed and used to generate magnetic anomaly maps shown below.

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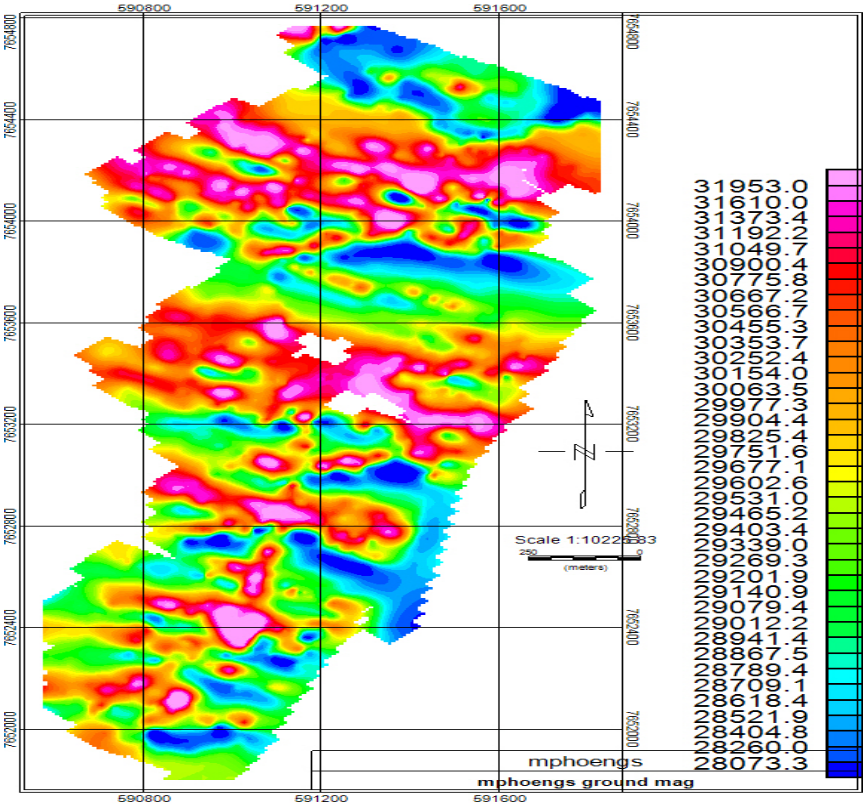

Figure 4.1: Magnetic image map of the survey site

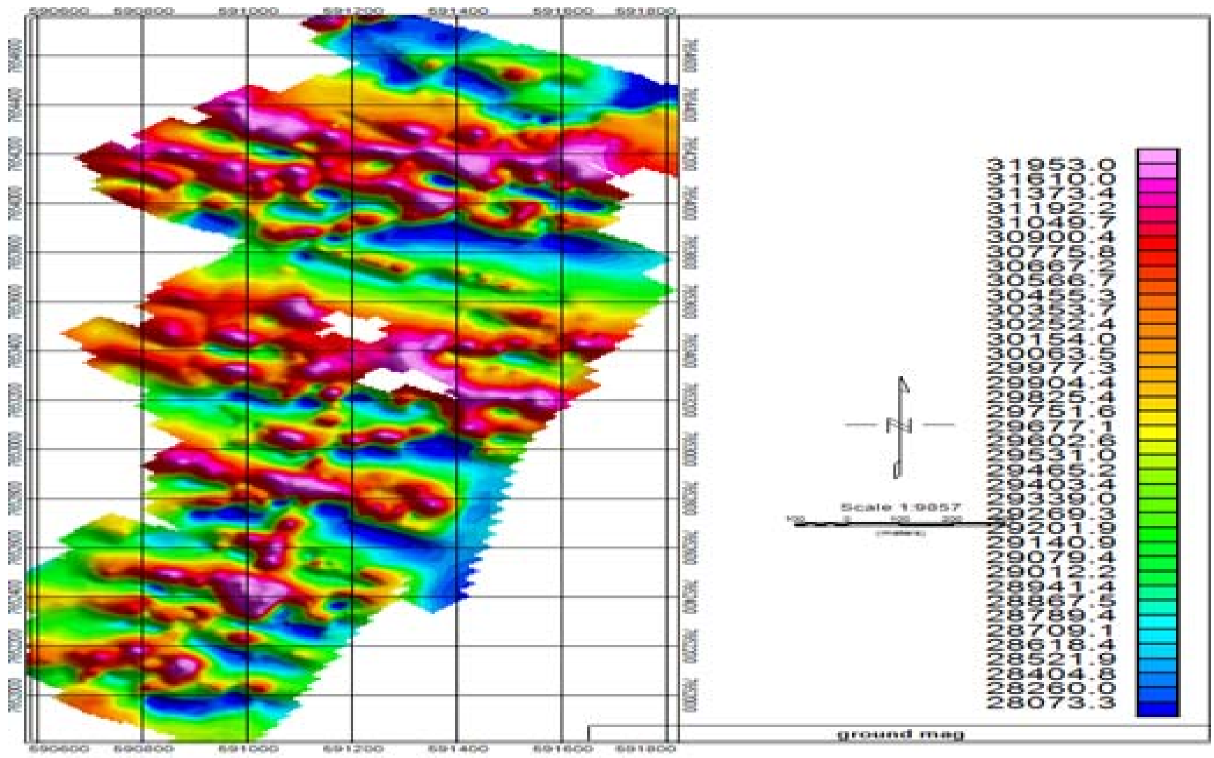

Figure 4.2: Colour shaded grid on the survey site.

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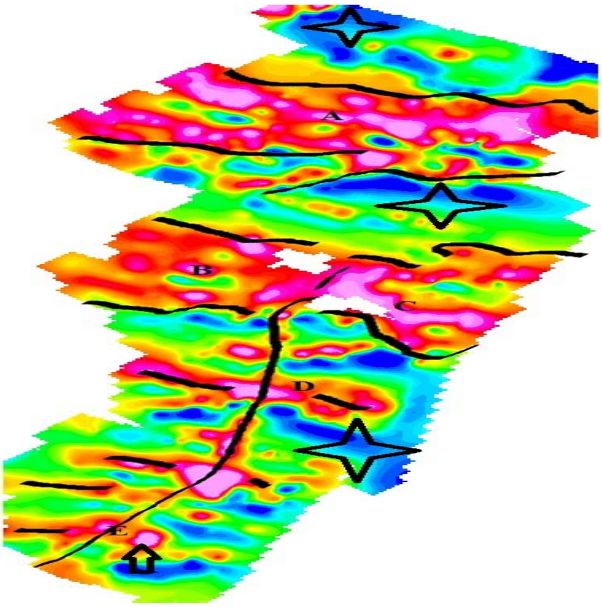

Figure 4.4: Interpreted HSV magnetic surveys

By looking at the magnetic map image of the Mphoengs survey site, in general it can be deduced that the area is highly magnetic with very small areas of low magnetic readings mainly to the south east and a deep low in the north east of the area. The areas with low magnetics are marked by the four-point stars. The low magnetic region to the north of the **A** is separated from the low magnetic region to the north of **B** by the region **A** which constitutes a region of two very high magnetic signatures strikes which run north west to south east and are separated by a thin region of magnetic low. These two strands may represent faults which are associated with disseminated sulphides that are associated with magnetic highs. Another magnetic high strand/fault is found in the magnetic low region, above **B** and it runs in the same direction as the faults stated above. Regions **B** and **C** are regions of magnetic highs, characterised by faults which are separated by a major, elongated fault which runs from the southernmost area of the survey area. The faults still run from northwest to south east, the same trend noted in the regions of **D** and **E** where numerous faults of magnetic highs are situated.

6. Conclusions

The magnetic signatures obtained from the surveyed area as presented on the maps above and described in the discussion, brings a very interesting and strong message about the nature of the subsurface at Mpoengs which is there for anyone interested to analyse and use. Based on these reliable results, it can be argued that the area has economic potential. Using the maps and the GPS one can zoom in and precisely concentrate on the regions with magnetic high signatures for economic exploitation of the resources embedded in mother earth. Evidence from geology suggest that those regions of high magnetic signatures are due to sulphide bodies and are possible for mining interest for gold minerals associated with disseminated sulphides. The main disadvantage of magnetic methods in locating mineshaft is when the in-fill material is similar in terms of magnetic properties with the surrounding rock mass (McCann 1987). This study showed that the magnetic method can be used successfully and accurately to distinguish and zero in on anomalies that uniquely identify potentially favorable areas for economic mining. In the next paper we shall present and discuss the results of induced polarization which we envisaged as a follow up method to the magnetic survey.

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Author Profile

Bernard Siachingoma has done Masters in Geophysics. Presently he is serving as Lecturer at Midlands State University, Zimbabwe. His research interests include Geophysics. He is also a PhD Scholar.

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