Using Induced Polarisation as a Follow up to Magnetic Method in Prospecting for Gold at Lady A Claims

Bernard Siachingoma[1], **RenisiaTipedze**[2]

[1]Geophyscs 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: ***Lady A Claims lie about 9km NNW of Concession, some 75km to the NNW of Harare. 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 meta-basalts. Based on the promising results from the magnetic surveys, induced polarization (IP) surveys were completed across all the six Lady A Claims in Concession. Gradient Array results show south-east north-west trending zones of high chargeability accompanied by low resistivity. There is a zone towards the eastern end of the blocks, which show high resistivity and high chargeability. High chargeability zones can be thought to correspond to zones associated with quartz veins. Real Section Induced Polarization (RSIP) was done over ten lines to determine the apparent behaviour of the anomalies with depth. The results from this survey showed the complicated nature of the ore-body with depth and along strike. Possible drilling targets were delineated along each of these lines.***

Keywords: greenstone belt, induced polarization, chargeability, anomalies, ore-body

1. Introduction

Induced Polarization (IP) is a current stimulated phenomenon observed as a delayed voltage response in earth materials. It is the most widely used geophysical surveying technique employed in exploration for metallic ores despite being the newest method and having high cost of equipment (Summer 1979, Lowrie 2011). This study is a result of a follow up induced polarization survey that was done at lady A claims after magnetic survey produced promising results. The main goal was to generate pseudo-geological and structural maps to aid in establishing beyond doubt areas potentially favourable for gold mineralization within the host rocks and confirm this by recommending drilling at chosen ideal sites. The IP survey was configured to assess the existence of disseminated sulphides associated with structures identified by the magnetic surveys. IP is good at picking disseminated concentrations of conducting ore minerals (Lowrie 2011). Identifying such sulphides is a major pointer for gold occurrence as sulphide minerals such as pyrite, chalcopyrite etc are usually associated with, and therefore pathfinders to economic gold occurrences.

Based on the results of the previous magnetic survey and more importantly this IP survey, three exploration shafts were sunk in three recommended localities with the aim of assessing the reef’s potential in the area. Although this paper is mostly focussed on the IP survey and its results, it inevitably links this to the physical geological mapping on exposed outcrops, magnetic survey data and completeness of the overall study of the project area will come after further reference data from the assay results obtained after the trial milling of ore taken from the recommended exploration shafts is done.

2. Theory

Geo-electric properties are exploited commercially in the search for valuable ore bodies which may be located by their anomalous properties (Lowrie 2011).The aim of the IP surveys is to detect and map possible sulphide mineralization as it is known that gold in this area is associated with pyritization. The IP method is widely used for detecting possible sulphide mineralization (usually an indicator for gold occurrence) that is expected to give high chargeability response. There are two main mechanisms of rock polarization which are grain polarization and membrane polarization (Milsom, 2003). Overvoltage effect is caused by minerals which are good conductors where its magnitude depends on both magnitude of impressed voltage and mineral concentration. It is most pronounced when the mineral is disseminated throughout the host rock as the surface area available for ionic–electronic interchange is then at a maximum. The effect decreases with increasing porosity as more alternative paths become available for the more efficient ionic conduction **(**Kearey et al., 2002).

In IP methods electrical current is alternately induced into the ground and switched off usually in cycles of 2 seconds. The induced current ionizes ground temporarily for 2 seconds, thereby creating a temporary cell in the ground that results in an "over voltage" which decays to zero during the off phase of the cycle. The size of the stored charge, and hence the time it takes for the over voltage to decay, depends on the presence of electrically chargeable minerals in the ground such as sulphides. Complex impedance measurements of materials have been made at least since 1941(Cole and Cole 1941, Grant 1958). In the hope that mineralized rocks would have a unique spectral signature (Van Voohris et al, 1973) did not find any significant variation than using earlier equipment. Although resistivity can also be obtained, the main parameter measured from IP survey is chargeability of minerals and rocks. Chargeability is defined as ratio of the area under the decay curve to the potential difference measured before switching the current off. True chargeability is the ratio of the over-or secondary voltage, Vs, to the observed voltage, Vo (Seigel, 1959). The chargeability figures of common minerals and rocks range from 0.2 for Hematite through 3.7 for Galena and 9.4 for chalcopyrite to 13.4 for pyrite (Telford et al, 1990).

The chargeability (m) in Millivolts/volts, of the ground is the rate of decay of voltage across this cell. True chargeability is the ratio of the over or secondary voltage Vs, to the observed voltage (Vo), applied thru AB so that M= Vs/Vo, expressed as a percentage or as millivolts per volt. In reality, what is measured is the apparent changeability (Ma) which is the area (A) beneath the voltage-time decay curve over a defined time interval T1 to T2 and normalized by the assumed steady-state primary voltage, Vp such that

Ma =A/Vp=$(1/Vp) \times \int_{t2}^{t1} v(t)dt$, in units of mVs/V.

Knowing the location of the electrodes and measuring the amount of current input into the ground and the voltage difference between two potential electrodes we can compute the resistivity of the medium. The resistivity computed is referred to as the apparent resistivity. We call it the apparent resistivity because the earth does not have a constant resistivity or a homogenous medium i.e. it varies both with depth and horizontally. Besides disseminated sulphides, other minerals such as graphite, oxides and clays are also possible sources of IP anomalies and they define chargeability anomalies. Because all these minerals are conductors they tend to give low resistivity anomalies. However, high resistivity is possible within sulphide zones if they are hosted within resistive quartz veins or within silicified zones.

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.

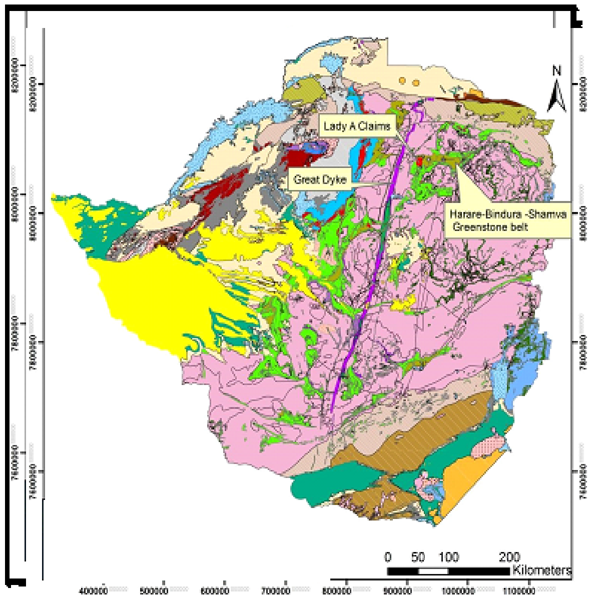

Figure 1: Geological Map of Zimbabwe

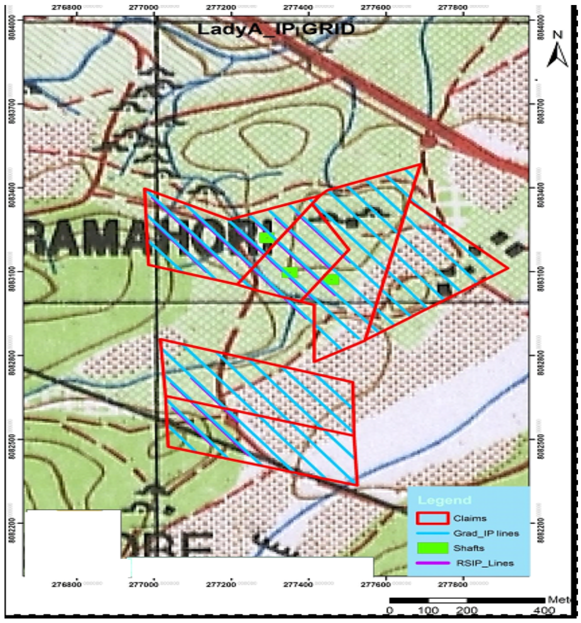

Figure 2: Lady A IP Grid

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. Research Methodology

A 4Kwatt VIP 4000 time domain transmitter and a ten (10) Channel Iris Elrec Pro Receiver were used. The electrical current input was transmitted via 2mm diameter electric cables with a tolerance of 5000 Volts. Steel pegs were used as current electrodes on adequately prepared ground to ensure good signal.

The Gradient Arraysurvey was conducted using a dipole size of 25m with station move ups of 25m. The Real Section Induced Polarisation (RSIP) array was employed using different current electrode separations (AB) to investigate varying depth levels (AB/2) of 50, 75, 100, 150 and 200 metres below the ground. Potential electrode dipole separations (MN) of 25 metres were used for levels 50, 75 and 100 while a dipole separation of 50m was used for the deeper levels of 150 and 200m.

Special attention is taken to ensure best possible contact resistance (k-Ohm) prior to acquisition. Some data points are repeated and saved in the field for quality control purposes. Particular attention is also given to the Primary voltages to see if they are above the noise levels in the area thus about 10mV and the decay curves. This insures that we are injecting a clean signal given the best possible result. The curves are monitored by the operator in real time while taking measurements and every effort is made to ensure the maximum quality of the decay curve. Apparent resistivity and total chargeability are calculated by the ELEREC_PRO receiver.Further analysis of decay curves was done during processing prior to producing final plots. A depth estimate calculation was made for the remaining data after undergoing QA and QC processes. The depth is treated as an apparent depth due to charges encounter at surface and depth which have not been accounted for. Geosoft software was used to process the data. The data was presented as colour plan maps and RSIP Section plots.

5. Results and Discussion

Figure 4: Gradient IP map, current& old mine claims

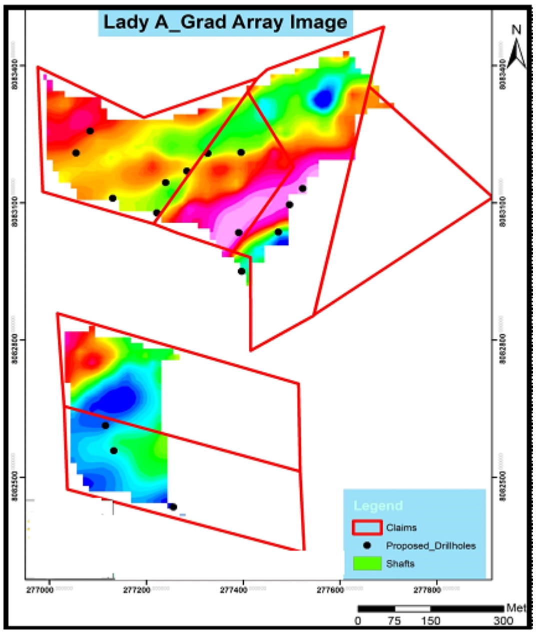

Figure 4: Composite map, claims & drill hole

In the diagrams, figure 3 is aGradient IP map showing the position of current workings and old mine in the claims. The black dot shown on the map is Dawn Mine, and the blue squares show the current shafts. Figure 4 shows Composite map showing the main shaft, IP trend, Claims and the proposed drill-holes.

Real Section Induced Polarisation (RSIP) survey was done on selected lines across the gradient array anomaly. The lines were chosen to those with the largest extended after having lost some ground due to farming activity in the area. The Real Section Results are presented as Chargeability and Resistivity Depth Sections also showing the position of the current workings and the proposed drill holes basing only on the combination of the IP effects and resistivity. A plan map combining all the RSIP Sections and plotted on the 50m apparent depth is shown giving the position of the proposed holes as well.

Gradient IP: Looking at figure 7, a highly chargeable zone is evident on the northern grid with a NE-SW trend. This appears to extend to the northern part of the southern block. There is also another relatively high chargeability zone concentrated on the northern ends of line 450 to 600 and unfortunately, it seems to extend to the areas outside the Claim boundaries. A moderately chargeable zone is also present, which is the green colour evident on the image and has got a good resistivity combination. A high resistivity also follows the same trend as the chargeability described above.

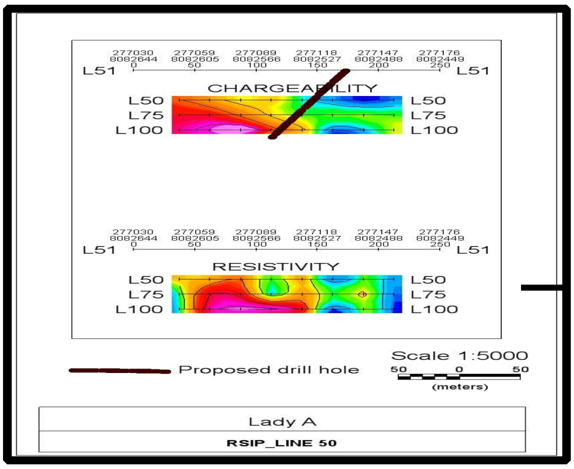

Figure 5: RSIP image along line 50 Southern block

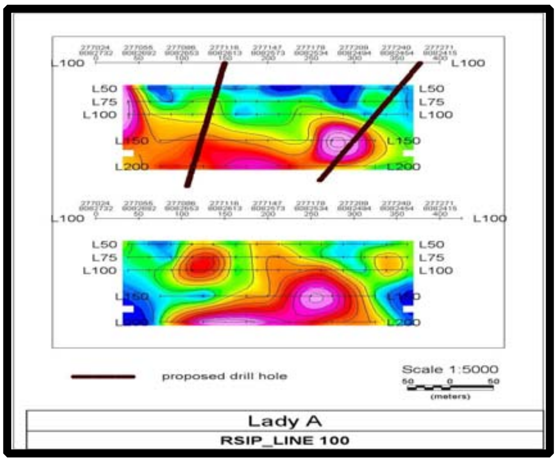

Figure 6: RSIP image along line 100 on the southern block

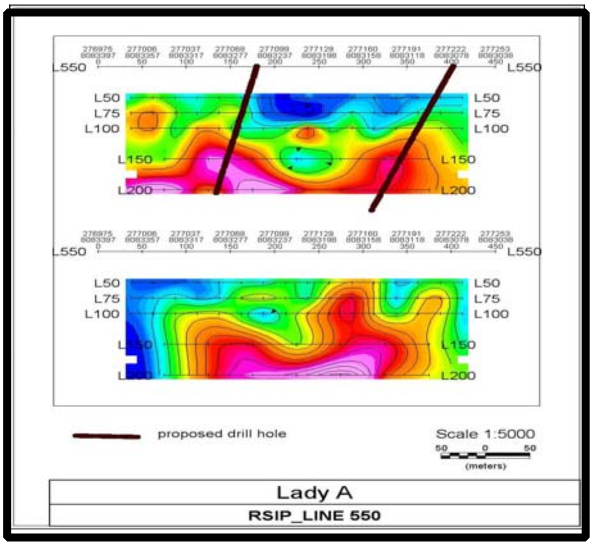

Figure 7: RSIP image along line 550 on the Northern block

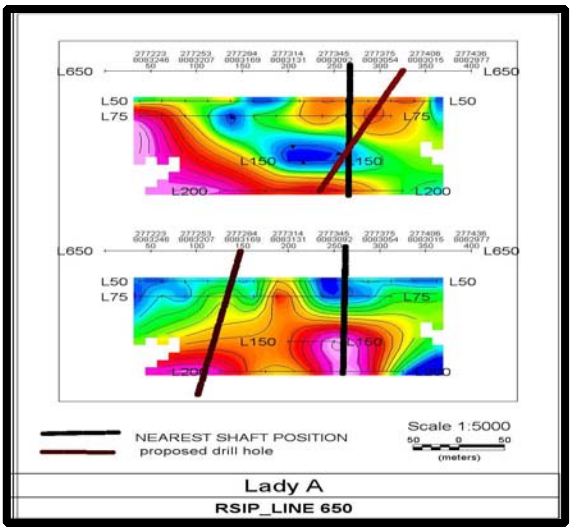

Figure 8: RSIP image along line 650 on the Northern block

6. Conclusions and Recommendations

All Chargeability anomalies regardless of values are potential targets for mineralization and need further investigations using more direct methods, mostly drilling. The more prominent anomalies have been identified as good, moderate to very good IP anomalies on the interpretation maps above. The weak IP anomalies can only be followed up after the good and moderate to very good categories depending on availability of resources.

More claims should be acquired in this area, preferably on the north and west of the southern block covering zones with high chargeability anomalies which seem to connect to the northern block. Meanwhile, an initial drilling is proposed on a reconnaissance basis based on the IP anomalies generated. A drilling plan was designed based on the geology and geophysical anomalies. The magnetic survey was a good pointer to area with good mineralization because its overall effect tallied well with the geological mapping on exposed outcrops, the IP survey and existing small scale mining.

References

[1] Campbell, S.D.G., and Pitfield, P.E.J., 1994, Structural controls of gold mineralization in the Zimbabwe Craton – Exploration Guidelines, Zimbabwe Geological Survey, Bulletin 101.
[2] Lettner, E.G., 1974, The Geology of the Country around Mount Darwin, Zimbabwe Geological Survey, Bulletin **73.**
[3] Cole K.S and Cole R.H, 1941, Dispersion and Absorption in Dielectrics, Alternating Current fields; Journal of Chem. Phy. V.9, p. 341
[4] Grant F.S, 1958, Use of complex conductivity in the representation of dielectric phenomena; Journal of Applied Physics V.9, p. 76-80
[5] Van Voorhis G.D, Nelson P.H and Drake T.L, 1973, Complex resistivity Spectra of Porphyyry Copper mineralization, Geophysics V.38 P. 49-60

[6] Summer J.S., 1979, The Induced Polarization Method in Geophysics and Geochemistry in the search for metallic ores, Geological Survey of Canada, Economic Geology report 31 P. 123-133
[7] Lowrie W., 2011, Fundamentals of Geophysics, Cambridge University Press, UK, Second edition, p. 252-271
[8] Telford, W.M. and Sheriff R.F., 1990, Applied Geophysics, 2nd edition, Cambridge
[9] University Press
[10] Kearey, P., Brooks M. and Hill I. (2002) "An Introduction to Geophysical Exploration," 3rd edition, Blackwell Science, p. 183-203.
[11] Milsom, J. (2003) "Applied Geophysics," 3rd edition, John Wiley & Sons Ltd., p. 83-126
[12] Seigel H.O, 1959, A theory for induced polarization for induced polarization effects in J.R Wait, ed., Overvoltage research and geophysical application applications, London peramon Press, p. 4-22

Author Profile

Bernard Siachingoma is a PhD Student and did Masters in Geophysics. Lecturer at Midlands State University, Zimbabwe Research Interest is Geophysics.