

Abstract

A geophysical survey was carried out at Lorna Doone farm, a dairy farm located 40 km from the Harare city centre. The study area lies within the Harare – Bindura – Shamva greenstone belt. Rocks in the area include meta-andesites, white quartz and greenstones.

The objective of the study was to find zones of possible gold mineralization associated with disseminated sulphides on Lorna Doone farm. Two geophysical methods were employed: the ground magnetic method and the induced polarisation method. The survey was carried out from the 15th of June to the 17th of July 2006.

Both the magnetic and the induced polarisation methods were successful in delineating subsurface structures and locating possible zones of gold mineralization. The ground magnetic method revealed two major anomalous zones, namely the Southern and Northern magnetic high anomalies. The Northern magnetic high anomaly has a NW-SE trend and an average width of 50 m. It has a strike of about 1 km. The Southern magnetic high is offset from the Northern anomaly by about 140 m. It has a similar trend and its strike length is 400 m.

The induced polarisation method revealed five anomalous zones. These are the Eastern IP1, Western IP1, Western IP2, Southern IP1 and the Northern IP1 anomalies. The Eastern IP1 and the Northern IP1 anomalies are coincident with the magnetic high anomalies. The Eastern IP1 anomaly is interpreted as being due to magnetite or massive sulphides, whilst the Southern IP1 anomaly could be due to both disseminated and massive sulphides and/or magnetite. The Western IP1, Western IP2 and the Northern IP1 anomalies are inferred to be due to disseminated sulphides.

Acknowledgements

I would like to thank all those who made valuable contributions for the success of this project and these include:

Dr J. Gore my supervisor for the constructive criticisms;

Dr O. Gwavava, my course coordinator and fieldwork supervisor, for his tireless efforts during data collection and for teaching me Geosoft;

Dr F. Podmore, Dr R. Owen and Professor D.L. Jones for teaching me various courses during my Masters programme;

The Geological Survey of Zimbabwe for supplying the induced polarization equipment;

The Zimbabwe School of Mines for providing the magnetometers;

The Geological Survey staff, Mr M. Mutenda and all the farm workers for helping me during data collection;

Dr and Mrs C. Bandason and family for making this project available and for providing accommodation and food during data collection;

My husband Judah Magaya for the financial and moral support;

My brothers Innocent, Simbarashe and Loverage and my parents for all their encouragement, support and motivation;

All my classmates: Mr Solomon Gumbie, Mr Blessed Munyamana and Mr Tawanda Mudereri for their support during my studies.

To God is all the glory.

List of Contents

	Page
Abstract	i
Acknowledgements	ii
List of Contents	iii
List of Figures	vii
List of Tables	ix
1. Introduction	1
1.1 Background	1
1.2 The Survey Area	2
1.3 Regional Geology	4
1.3.1 The Iron Mask Formation	4
1.3.2 The Arcturus Formation	6
1.4 Local Geology	6
1.5 Present Geophysical Work	8
2. The Magnetic Survey	9
2.1 Introduction	9
2.2 Theory	10
2.2.1 The Earth's Magnetic Field	10
2.2.2 The Geomagnetic Elements	11
2.2.3 Variations with Time in the Earth's Magnetic Field	13
2.2.3.1 Secular Variations	13
2.2.3.2 Diurnal Variations	13
2.2.3.3 Magnetic Storms	14
2.2.4 Magnetization of Rocks	14
2.2.4.1 Induced Magnetization	15
2.2.4.2 Remanent Magnetization	15
2.2.5 Susceptibility of Rocks	15
2.3 Instrumentation	16

	Page
2.3.1 Field Procedures	17
2.3.2 Problems Encountered	18
3. Induced Polarization	19
3.1 Introduction	19
3.2 Theory	20
3.2.1 Electrode Polarization	21
3.2.2 Membrane Polarization	22
3.2.3 Chargeability	23
3.2.4 Resistivity	24
3.2.5 Negative IP and Masking	25
3.3 Instrumentation	25
3.3.1 Field Procedures	26
3.3.2 Precautions	27
3.3.3 Problems Encountered	27
4. Magnetism Data Processing, Presentation and Results	28
4.1 Data Processing and Presentation	28
4.1.1 Introduction	28
4.1.2 Magnetic Signatures of Rocks, Structures and Ore Environments	29
4.1.3 Depth Estimations	31
4.1.4 Diurnal Corrections	33
4.1.5 Magnetic Maps	35
4.1.5.1 The Magnetic Profile Map	35
4.1.5.2 The Reduction to the Pole Map	36
4.1.5.3 The Analytic Signal Map	36
4.1.5.4 The Power Spectrum Map	37
4.2 Results	39
4.2.1 The Magnetic Profile Map	40
4.2.2 The Total Field Magnetic Anomaly Map	42
4.2.3 The Reduced to the Pole Map	42

	Page
4.2.4 The Power Spectrum Map	45
4.2.5 The Analytic Signal Map	45
5. Induced Polarisation Data Processing, Presentation and Results	48
5.1 Data Processing	48
5.2 Data Presentation: Pseudosections	49
5.3 Results	50
5.3.1 Introduction	50
5.3.2 Contour Maps	51
5.3.3 Pseudosections	58
5.3.3.1 Line 1E	58
5.3.3.2 Line 2E	61
5.3.3.3 Line 3E	61
5.3.3.4 Line 4E	61
5.3.3.5 Line 5E	65
5.3.3.6 Line 6E	65
5.3.3.7 Line 7E	68
5.3.3.8 Line 8E	68
5.3.3.9 Line 9E	71
5.3.3.10 Line 10E	71
5.3.3.11 Line 11E	71
5.3.3.12 Line 12E	75
5.3.3.13 Line 13E	75
5.3.3.14 Line 14E	75
5.3.3.15 Line 15E	79
5.3.3.16 Line 16E	79
5.3.3.17 Line 17E	79
5.3.3.18 Line 18E	83
5.3.3.19 Line 19E	83

	Page
5.3.3.20 Line 21E	86
5.3.3.21 Line 22E	86
5.3.3.22 Line 23E	86
5.3.3.23 Line 24E	90
5.3.3.24 Line 25E	90
6. Interpretation, Conclusion and Recommendations	93
6.1 Interpretation of Magnetic Results	93
6.2 Interpretation of Induced Polarisation Results	95
6.3 Correlation of the Magnetic and Induced Polarisation Results	97
6.4 Discussion and Conclusion	99
6.5 Recommendations	100
References	101
Appendix A: GPS Positions and Magnetic Field Data	104
Appendix B: Magnetic Data Profiles	128
Appendix C: Induced Polarisation Field Data	141

List of Figures

	Page
Fig. 1.1 The topography map	3
Fig. 1.2 Geology of the Harare-Bindura-Shamva granite greenstone terrain, northern Zimbabwe	5
Fig. 1.3 The local geology map	7
Fig. 2.1 The field due to an inclined geocentric dipole	11
Fig. 2.2 The magnetic elements	12
Fig. 3.1 The dipole-dipole array	20
Fig. 3.2 Variation of observed voltage with time	21
Fig. 3.3 Electrode polarization	22
Fig. 3.4 Membrane polarisation associated with a constriction within a channel, between mineral grains	23
Fig. 4.1 The regional gradient, magnetically quiet zone and magnetically noisy zone	31
Fig. 4.2 Depth estimation using the straight slope method	32
Fig. 4.3 Variation of base station readings with time for day 1 (27 June 2006)	34
Fig. 4.4 Variation of base station readings with time for day 2 (28 June 2006)	34
Fig. 4.5 Depth estimation using a radially averaged power spectrum	39
Fig. 4.6 Profile map including cultural effects	41
Fig. 4.7 Total field map	43
Fig. 4.8 The reduced to the pole map	44
Fig. 4.9 The power spectrum map	46
Fig. 4.10 The analytic signal map	47
Fig. 5.1 Pseudosection plot for a dipole-dipole array	50
Fig. 5.2 IP contour map for $n = 1$	52
Fig. 5.3 IP contour map for $n = 2$	54
Fig. 5.4 IP contour map for $n = 3$	55

	Page
Fig. 5.5 IP contour map for $n = 4$	56
Fig. 5.6 IP contour map for $n = 5$	57
Fig. 5.7 IP contour map for $n = 6$	59
Fig. 5.8 IP pseudosections for Line 1E	60
Fig. 5.9 IP pseudosections for Line 2E	62
Fig. 5.10 IP pseudosections for Line 3E	63
Fig. 5.11 IP pseudosections for Line 4E	64
Fig. 5.12 IP pseudosections for Line 5E	66
Fig. 5.13 IP pseudosections for Line 6E	67
Fig. 5.14 IP pseudosections for Line 7E	69
Fig. 5.15 IP pseudosections for Line 8E	70
Fig. 5.16 IP pseudosections for Line 9E	72
Fig. 5.17 IP pseudosections for Line 10E	73
Fig. 5.18 IP pseudosections for Line 11E	74
Fig. 5.19 IP pseudosections for Line 12E	76
Fig. 5.20 IP pseudosections for Line 13E	77
Fig. 5.21 IP pseudosections for Line 14E	78
Fig. 5.22 IP pseudosections for Line 15E	80
Fig. 5.23 IP pseudosections for Line 16E	81
Fig. 5.24 IP pseudosections for Line 17E	82
Fig. 5.25 IP pseudosections for Line 18E	84
Fig. 5.26 IP pseudosections for Line 19E	85
Fig. 5.27 IP pseudosections for Line 21E	87
Fig. 5.28 IP pseudosections for Line 22E	88
Fig. 5.29 IP pseudosections for Line 23E	89
Fig. 5.30 IP pseudosections for Line 24E	91
Fig. 5.31 IP pseudosections for Line 25E	92
Fig. 6.1 The anomaly correlation map	98
Fig. B-1 Magnetic profile for Line 1E	128
Fig. B-2 Magnetic profile for Line 2E	129

	Page
Fig. B-3 Magnetic profile for Line 3E	129
Fig. B-4 Magnetic profile for Line 4E	130
Fig. B-5 Magnetic profile for Line 5E	130
Fig. B-6 Magnetic profile for Line 6E	131
Fig. B-7 Magnetic profile for Line 7E	131
Fig. B-8 Magnetic profile for Line 8E	132
Fig. B-9 Magnetic profile for Line 9E	132
Fig. B-10 Magnetic profile for Line 10E	133
Fig. B-11 Magnetic profile for Line 11E	133
Fig. B-12 Magnetic profile for Line 12E	134
Fig. B-13 Magnetic profile for Line 13E	134
Fig. B-14 Magnetic profile for Line 14E	135
Fig. B-15 Magnetic profile for Line 15E	135
Fig. B-16 Magnetic profile for Line 16E	136
Fig. B-17 Magnetic profile for Line 17E	136
Fig. B-18 Magnetic profile for Line 18E	137
Fig. B-19 Magnetic profile for Line 19E	137
Fig. B-20 Magnetic profile for Line 21E	138
Fig. B-21 Magnetic profile for Line 22E	138
Fig. B-22 Magnetic profile for Line 23E	139
Fig. B-23 Magnetic profile for Line 24E	139
Fig. B-24 Magnetic profile for Line 25E	140
Fig. B-25 Variation of total field values during the magnetic storm on 27/06/06	140

List of Tables

Table 4.1 Magnetic signatures	30
-------------------------------	----