An Interpretation of Magnetic, Gravity and Magnetotelluric Measurements over the Magondi Circular Magnetic Anomaly of Zimbabwe

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ACKNOWLEDGEMENT

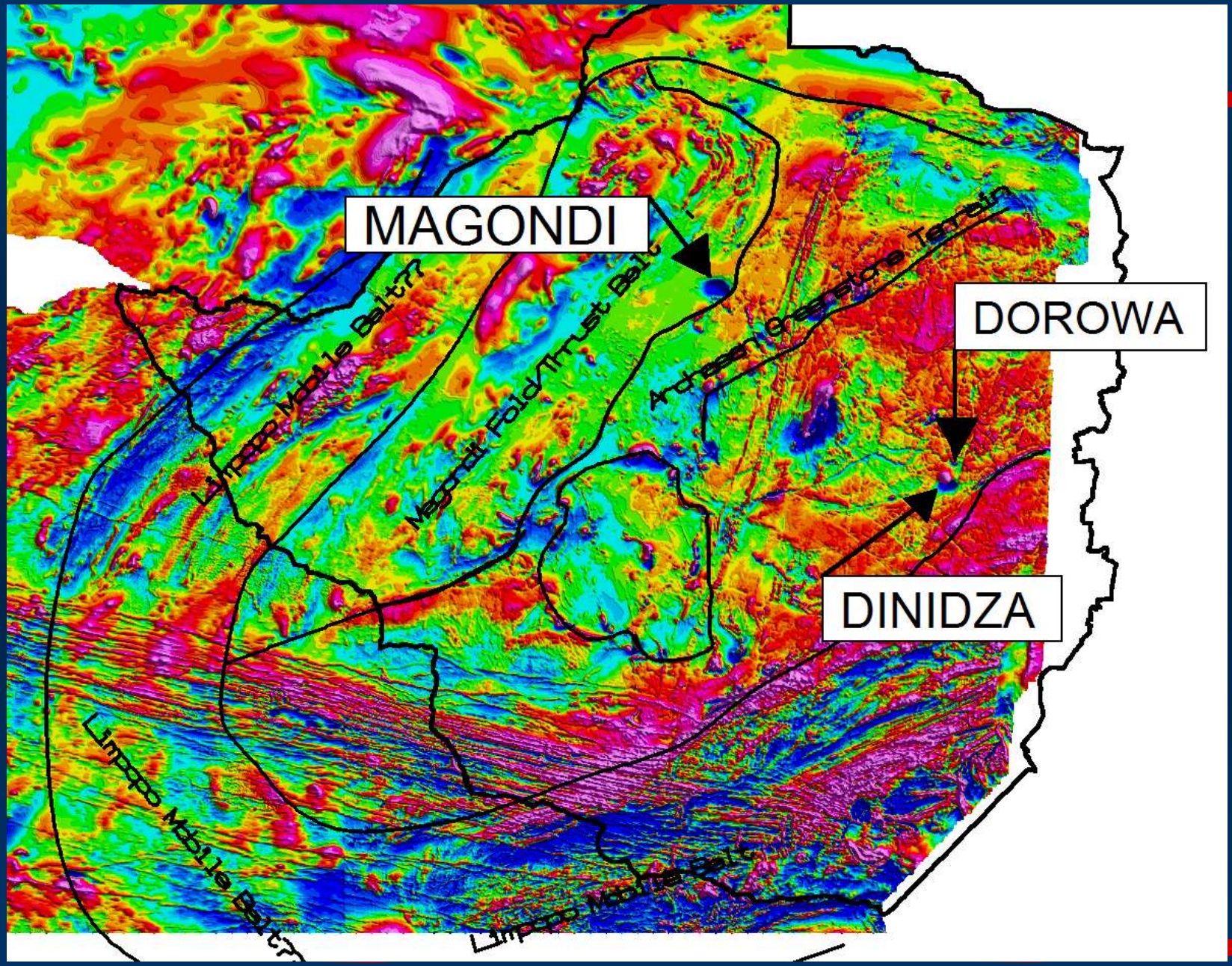
ANGLO AMERICAN CORPORATION

MAGONDI ANOMALY

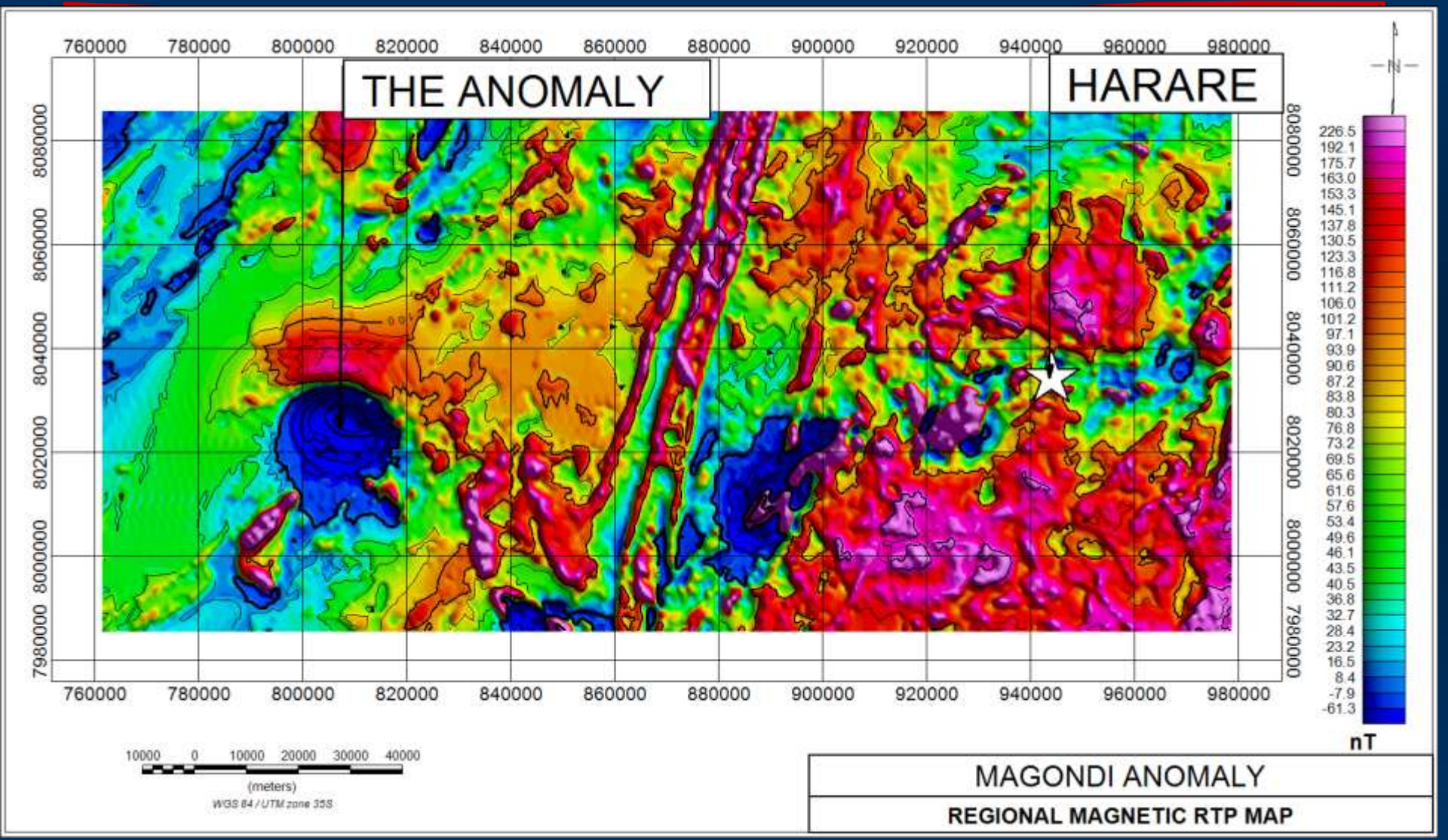
- ✓ CENTRE OF ANOMALY LIES 120KM WEST OF HARARE
- ✓ STRADDLES THE MUCHEKA-WA-KA SUNGABETA MOUNTAIN RANGE WHICH FORMS THE BOUNDARY OF MAKONDE AND ZVIMBA DISTRICTS
- ✓ GEOLOGY COMPRISES METASEDIMENTS OF LOMAGUNDI AND VOLCANO-SEDIMENTARY FORMATIONS OF THE DEWERAS GROUP

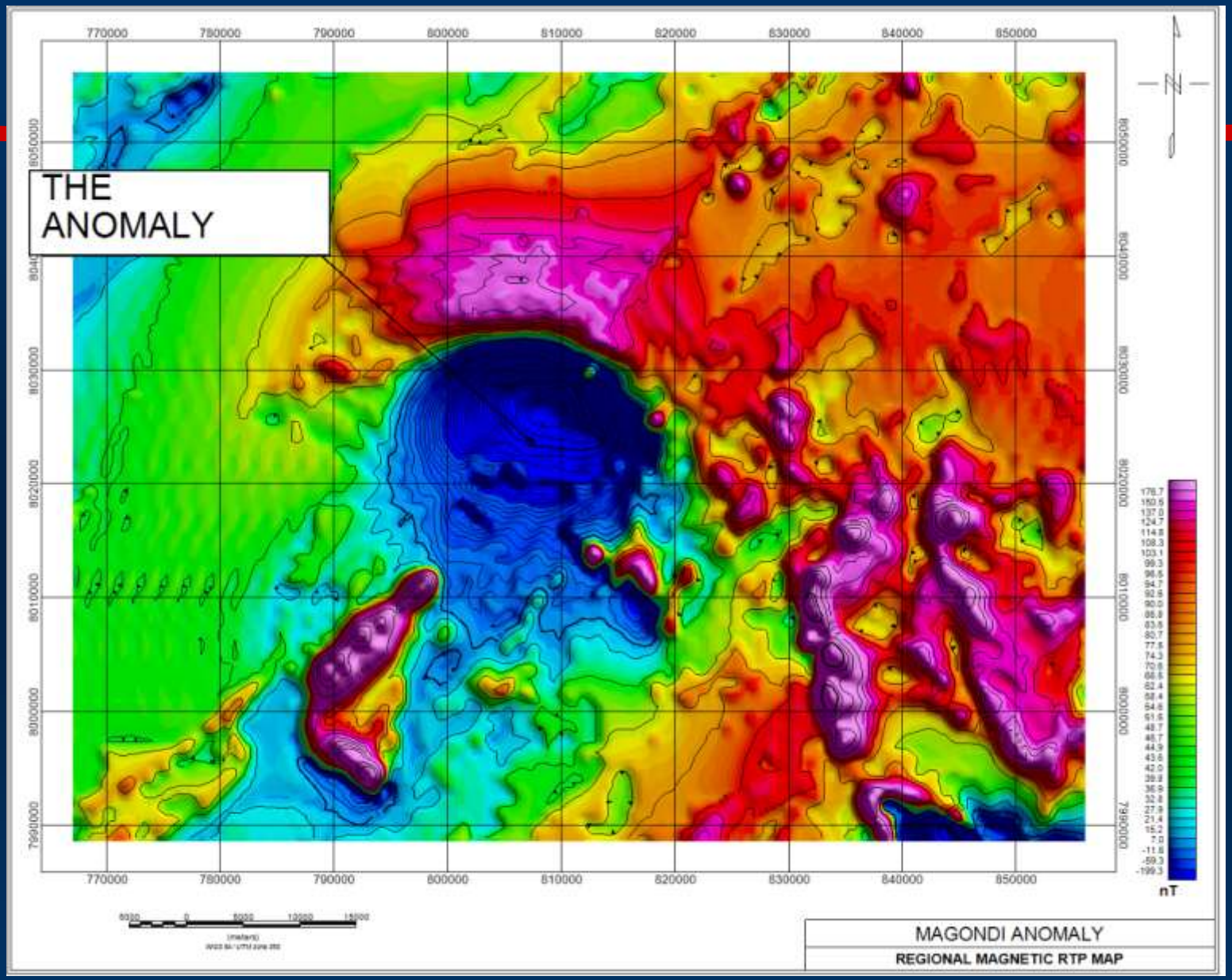
OBJECTIVES

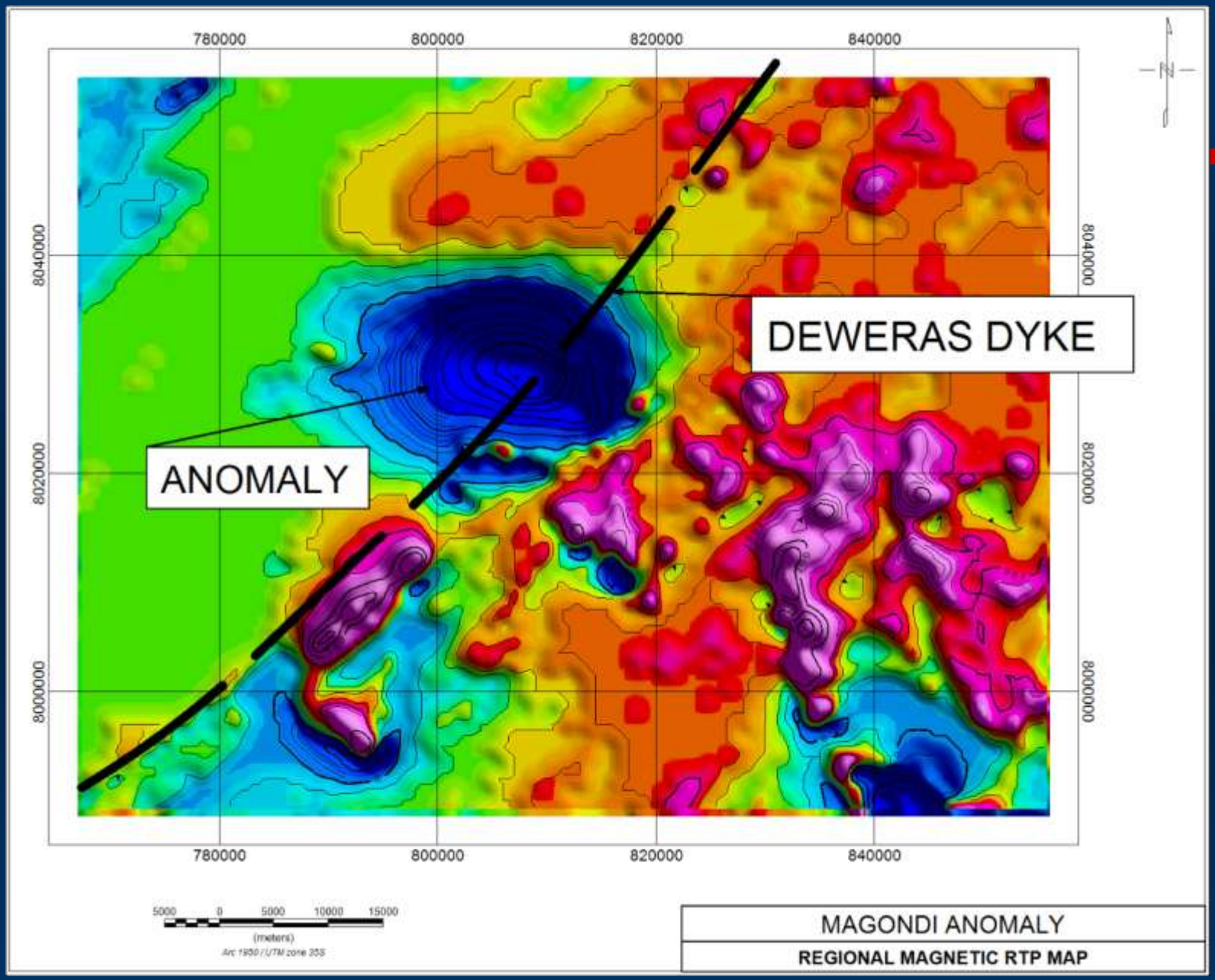
- ✓ EXPLAIN THE CAUSATIVE SOURCE OF BOTH THE MAGNETIC ANOMALY
- ✓ DENSE BODY WAS INFEERED TO BE MASSIVE SULPHIDES (3.4g/cc)
- ✓ EXCITED COMMERCIAL ENTITIES TO FUND THE EXPLORATION – THAT DENSITY CAN ONLY BE FOR MASSIVE SULPHIDES OF BASE METALS

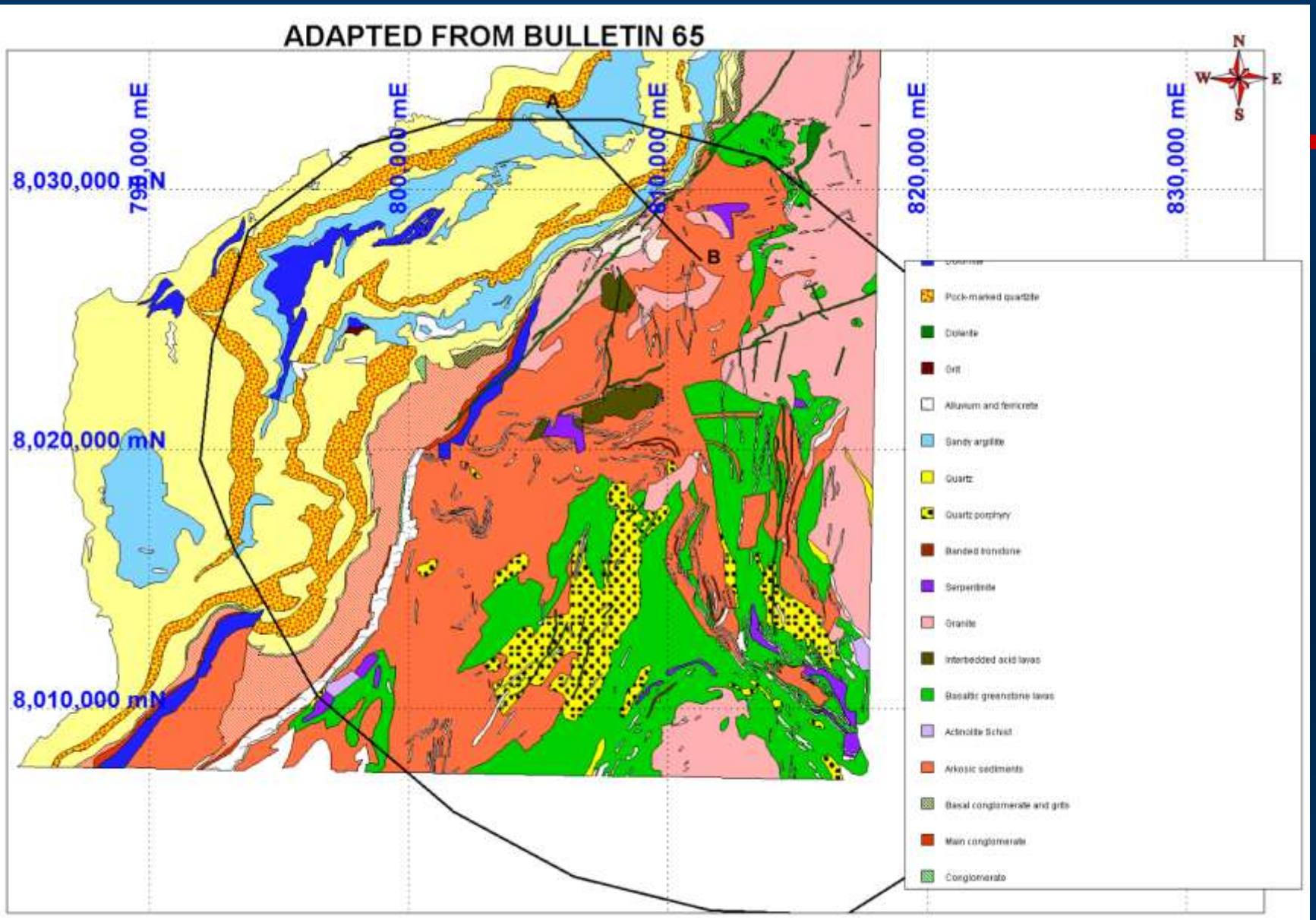

MAGONDI
DOROWA
DINIDZA
Limpopo Mobile Belt?
Megaridge Fold/Thrust Belt
Archean Greenstone Terrain
Limpopo Mobile Belt?
Limpopo Mobile Belt?

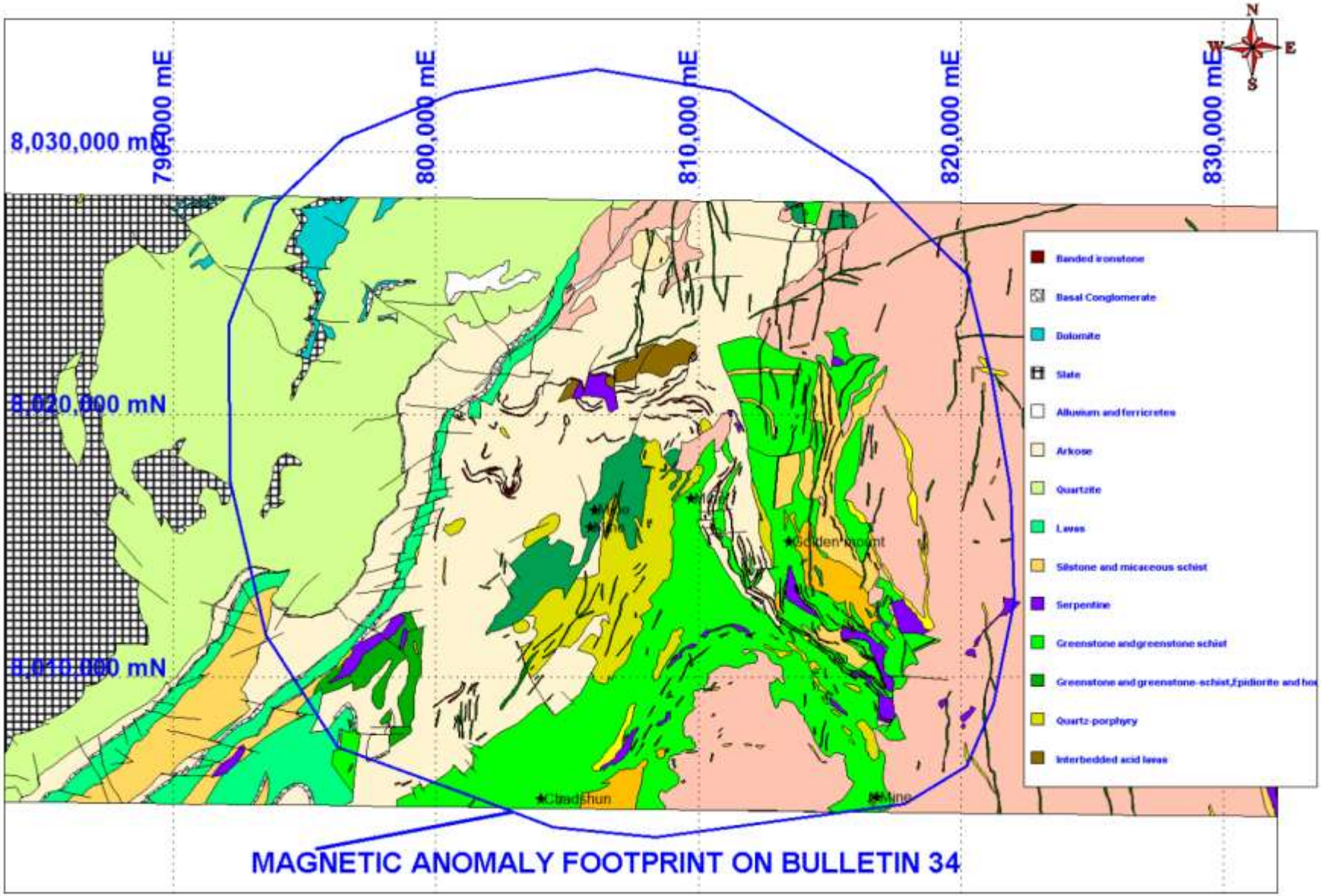
MAGNETICS


THE ANOMALY
HARARE
760000
780000
800000
820000
840000
860000
880000
900000
920000
940000
960000
980000
8080000
8060000
8040000
8020000
8000000
7980000
226.5
192.1
175.7
163.0
153.3
145.1
137.8
130.5
123.3
116.8
111.2
106.0
101.2
97.1
93.9
90.6
87.2
83.8
80.3
76.8
73.2
69.5
65.6
61.6
57.6
53.4
49.6
46.1
43.5
40.5
36.8
32.7
28.4
23.2
16.5
8.4
-7.9
-61.3
nT
10000 0 10000 20000 30000 40000
(meters)
WGS 84 / UTM zone 35S
MAGONDI ANOMALY
REGIONAL MAGNETIC RTP MAP

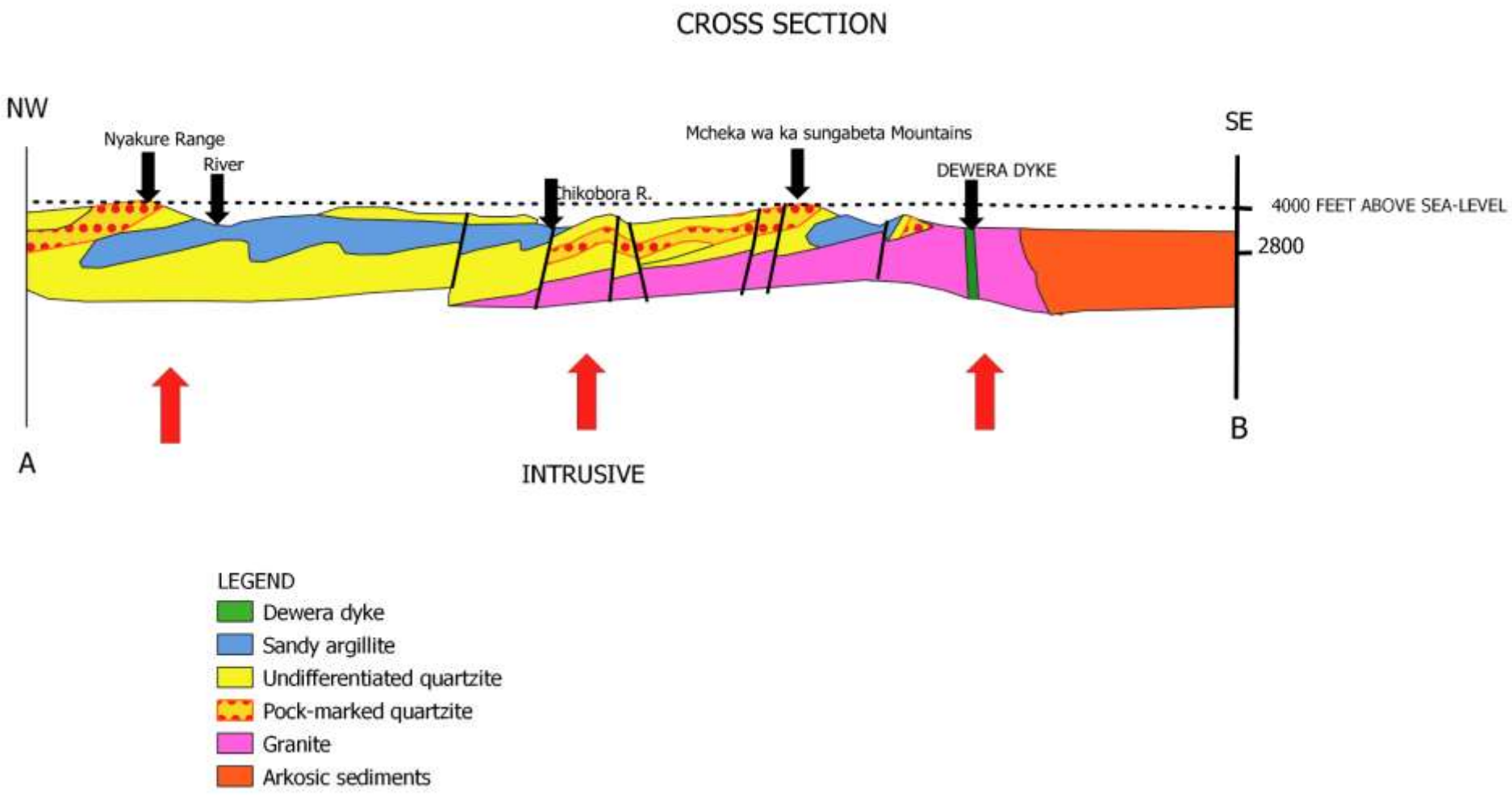

THE
ANOMALY
770000
780000
790000
800000
810000
820000
830000
840000
850000
8050000
8040000
8030000
8020000
8010000
8000000
7990000
nT
MAGONDI ANOMALY
REGIONAL MAGNETIC RTP MAP

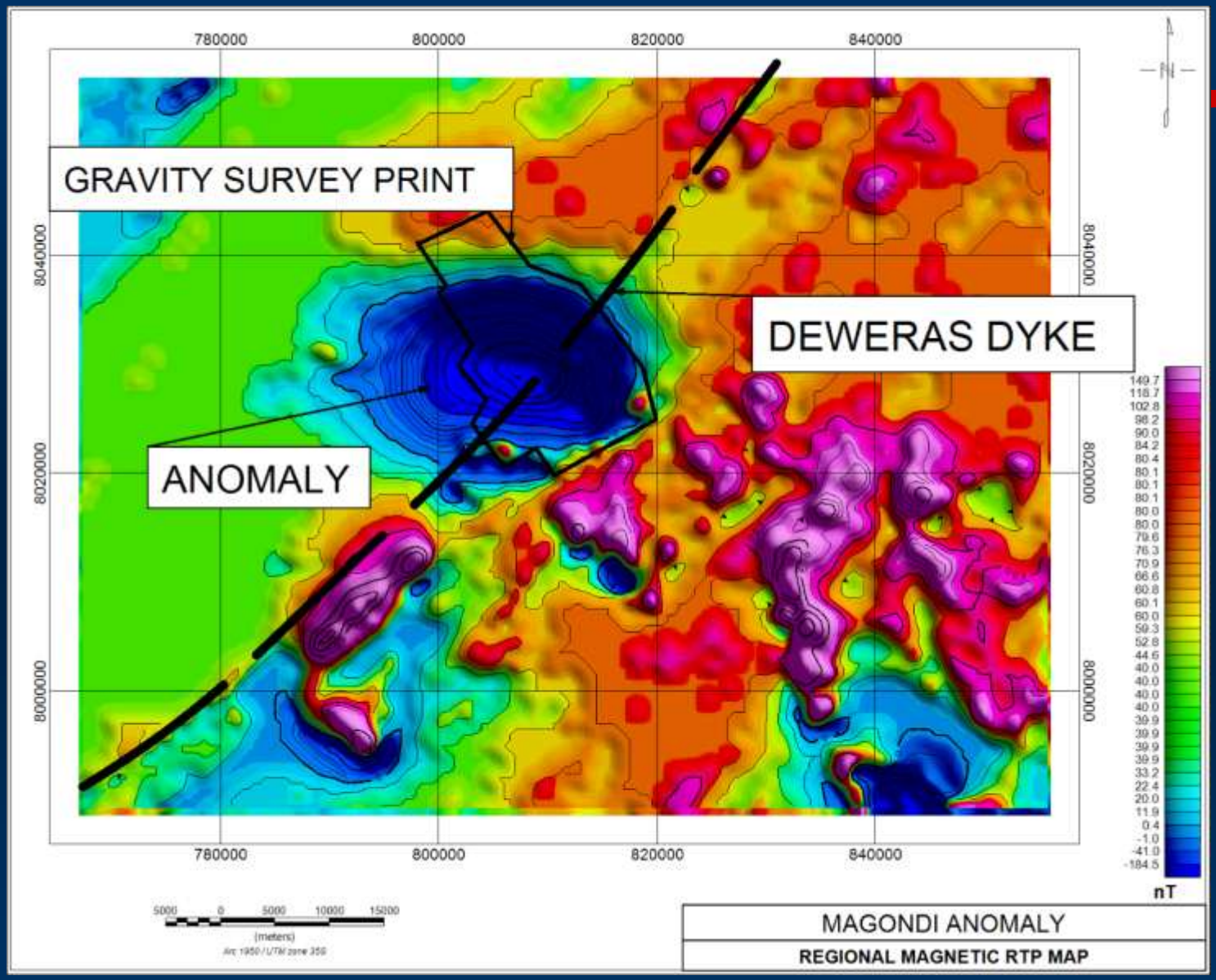

780000
800000
820000
840000
8040000
8020000
8000000
DEWERAS DYKE
ANOMALY
5000 0 5000 10000 15000
(meters)
Arc 1950 / UTM zone 35S
MAGONDI ANOMALY
REGIONAL MAGNETIC RTP MAP


ADAPTED FROM BULLETIN 65
N
W
E
S
790,000 mE
800,000 mE
810,000 mE
820,000 mE
830,000 mE
8,030,000 mN
8,020,000 mN
8,010,000 mN
A
B
Pock-marked quartzite
Dolerite
Grit
Alluvium and ferricrete
Sandy argillite
Quartz
Quartz porphyry
Banded ironstone
Serpentinite
Granite
Interbedded acid lavas
Basaltic greenstone lavas
Actinolite Schist
Arkosic sediments
Basal conglomerate and grits
Main conglomerate
Conglomerate

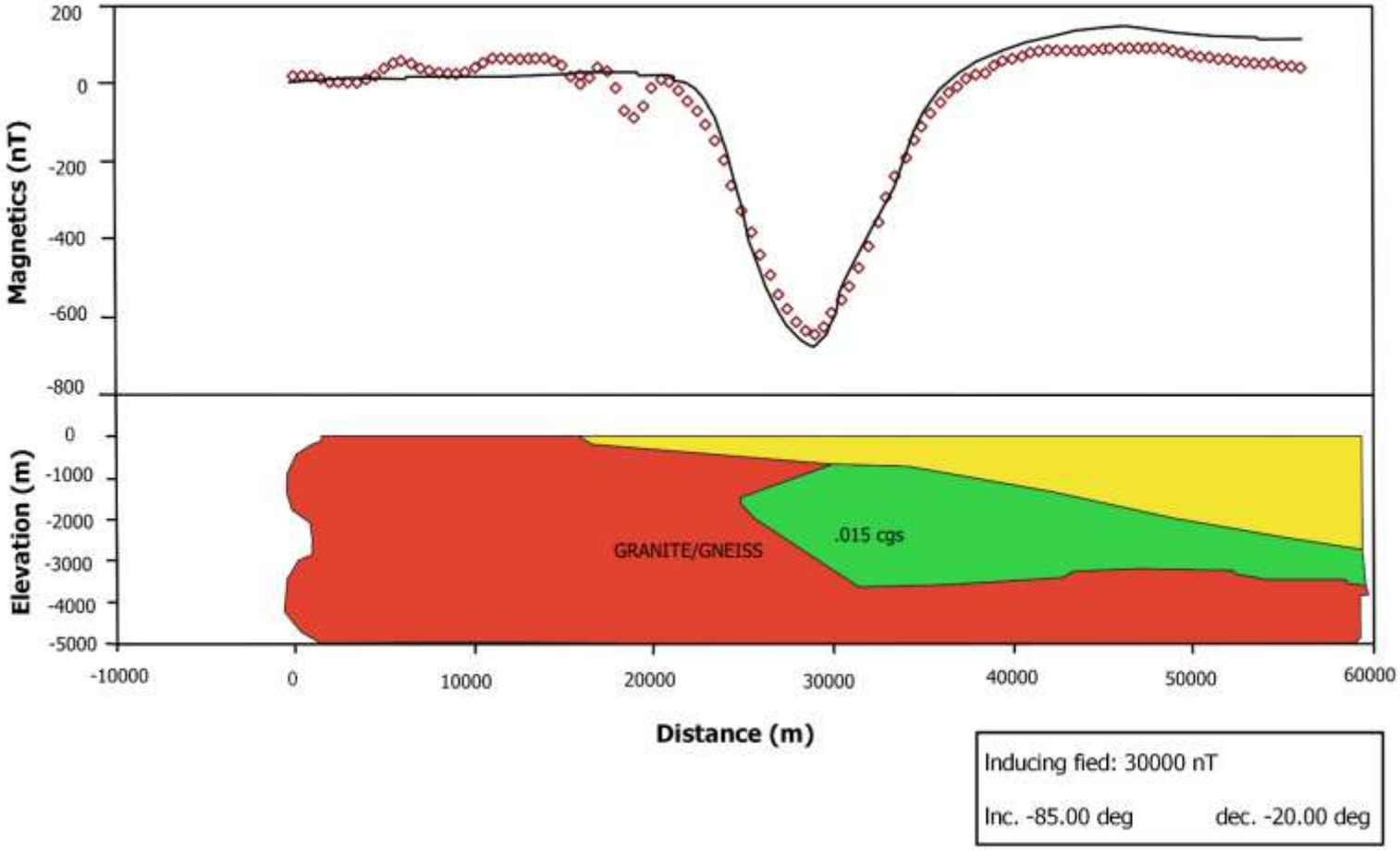


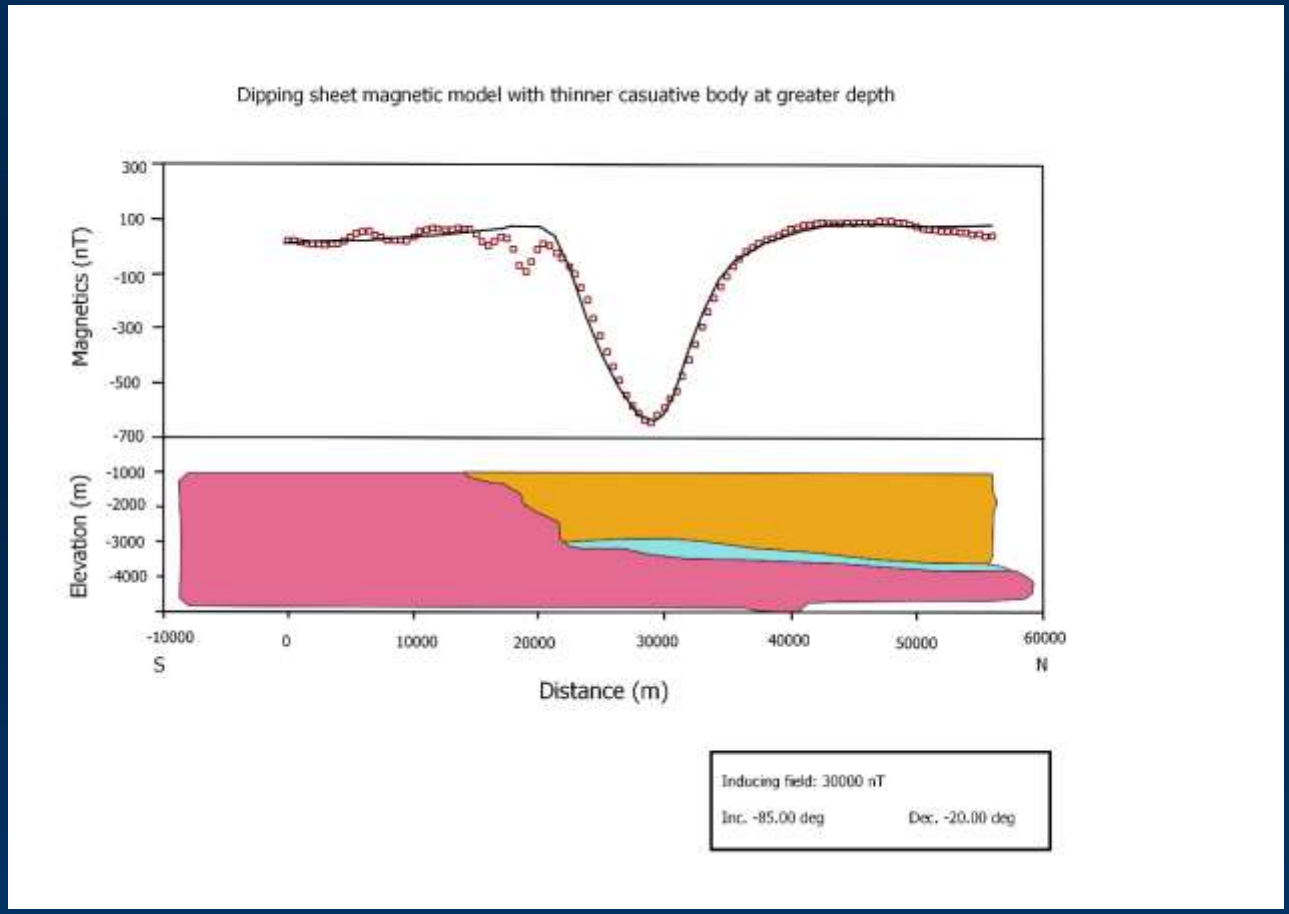
MAGNETIC ANOMALY FOOTPRINT ON BULLETIN 34


CROSS SECTION
NW
SE
Nyakure Range
River
Mcheka wa ka sungabeta Mountains
DEWERA DYKE
4000 FEET ABOVE SEA-LEVEL
2800
A
B
INTRUSIVE
LEGEND
Dewera dyke
Sandy argillite
Undifferentiated quartzite
Pock-marked quartzite
Granite
Arkosic sediments

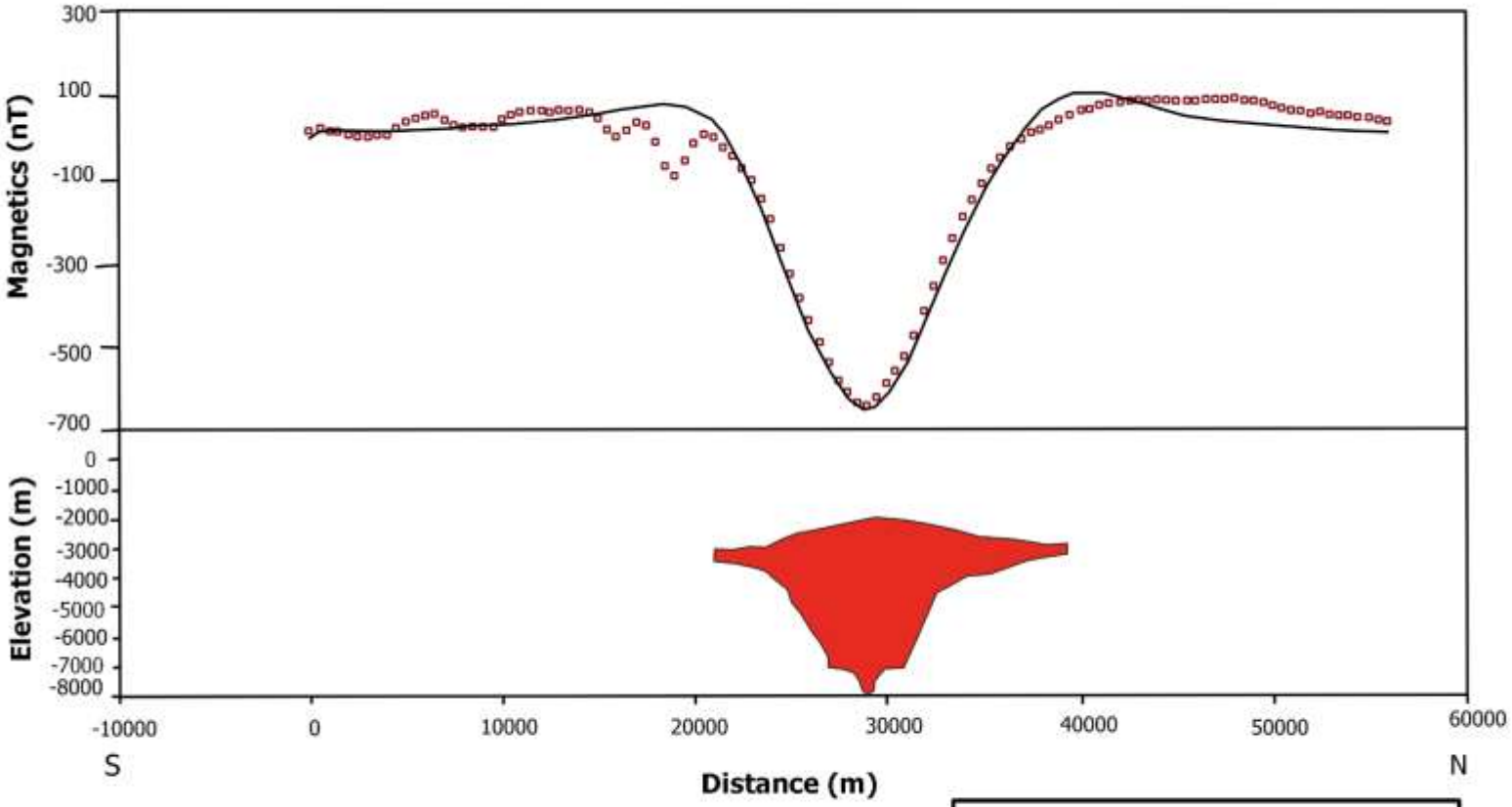

780000
800000
820000
840000
8040000
8020000
8000000
GRAVITY SURVEY PRINT
DEWERAS DYKE
ANOMALY
149.7
118.7
102.8
98.2
90.0
84.2
80.4
80.1
80.1
80.1
80.0
80.0
79.6
76.3
70.9
66.6
60.8
60.1
60.0
59.3
52.8
44.6
40.0
40.0
40.0
40.0
39.9
39.9
39.9
39.9
33.2
22.4
20.0
11.9
0.4
-1.0
-41.0
-184.5
nT
5000 0 5000 10000 15000
(meters)
Arc 1950 / UTM zone 35S
MAGONDI ANOMALY
REGIONAL MAGNETIC RTP MAP

Dipping sheet magnetic model with thick shallow casuative body



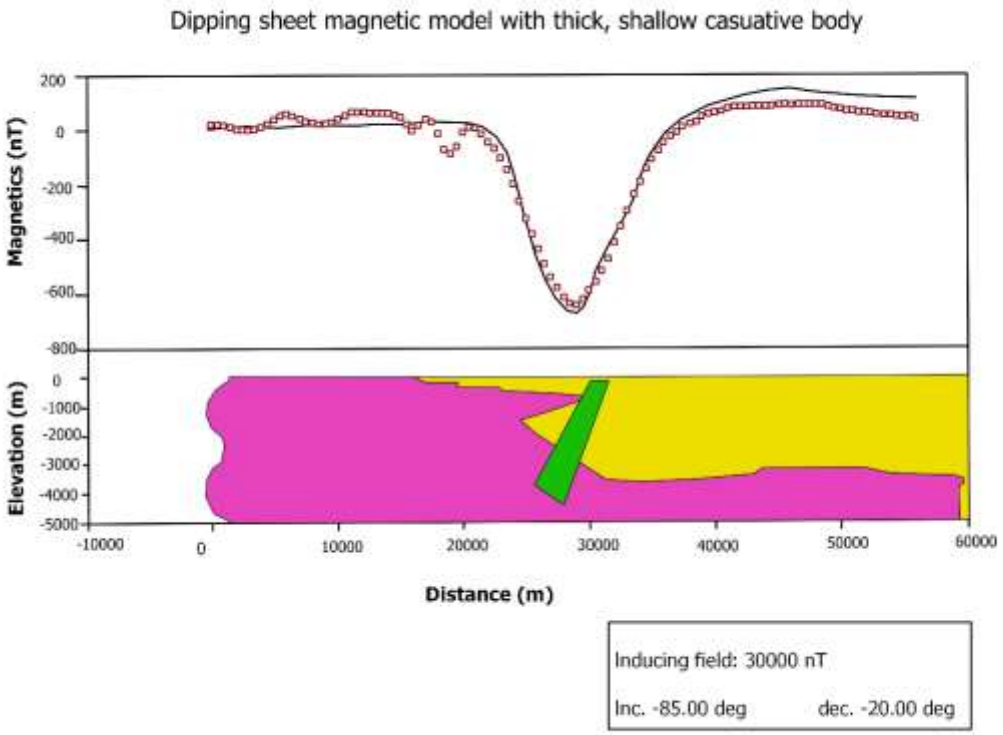

Dipping sheet magnetic model with thinner casuative body at greater depth
Magnetics (nT)
300
100
-100
-300
-500
-700
Elevation (m)
-1000
-2000
-3000
-4000
-10000
0
10000
20000
30000
40000
50000
60000
S
N
Distance (m)
Inducing field: 30000 nT
Inc. -85.00 deg
Dec. -20.00 deg

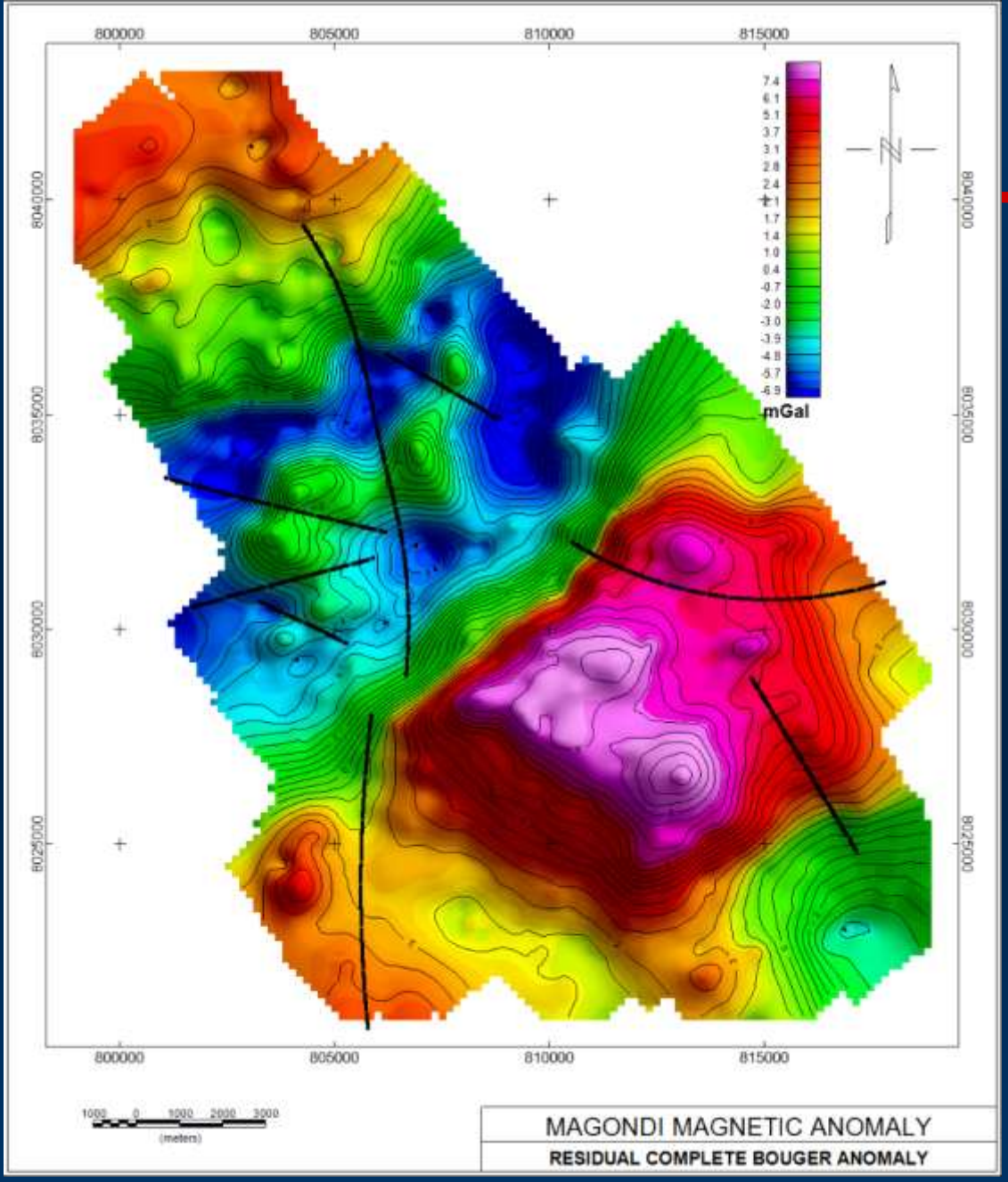
Magnetic model with diapiric structure

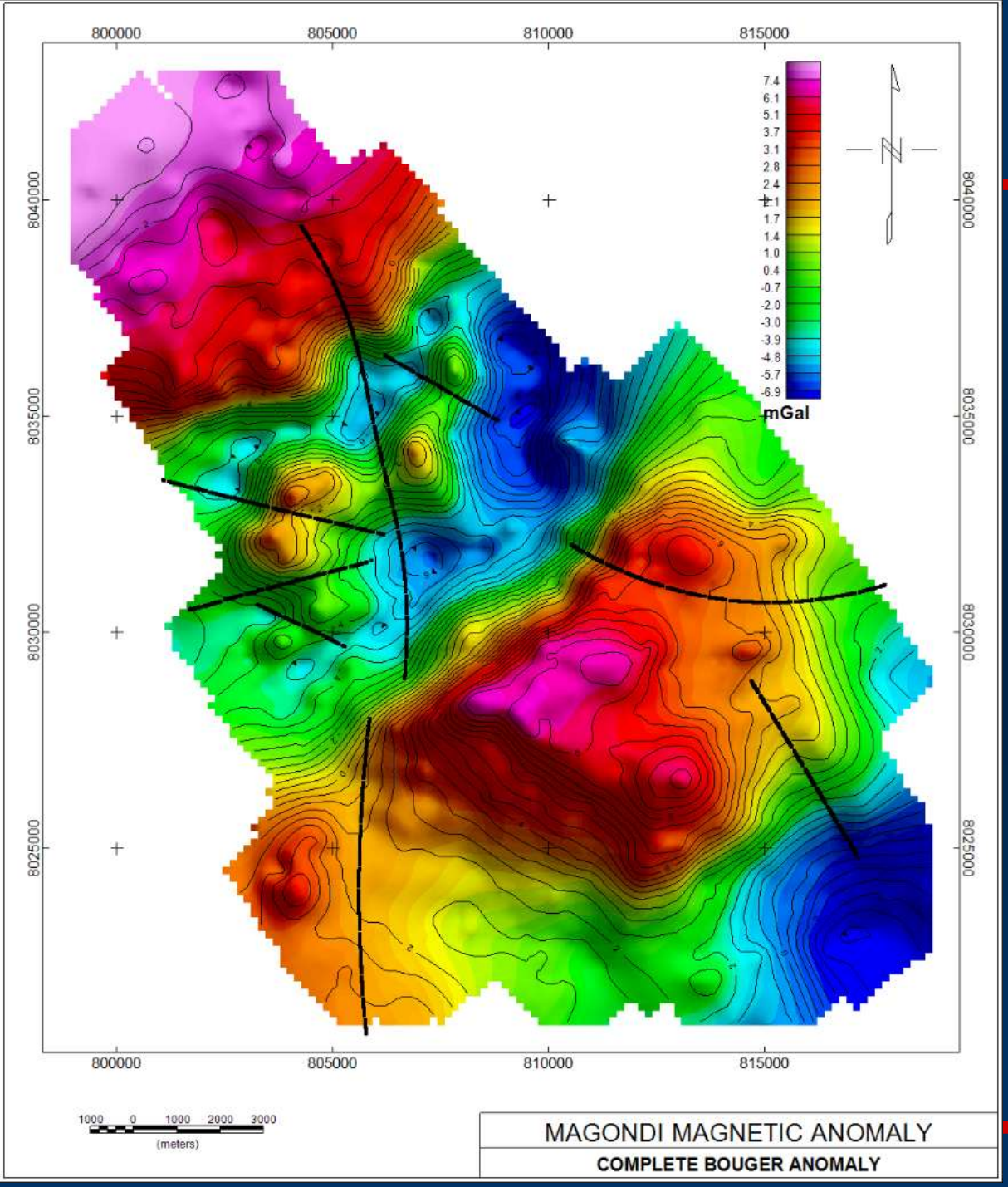


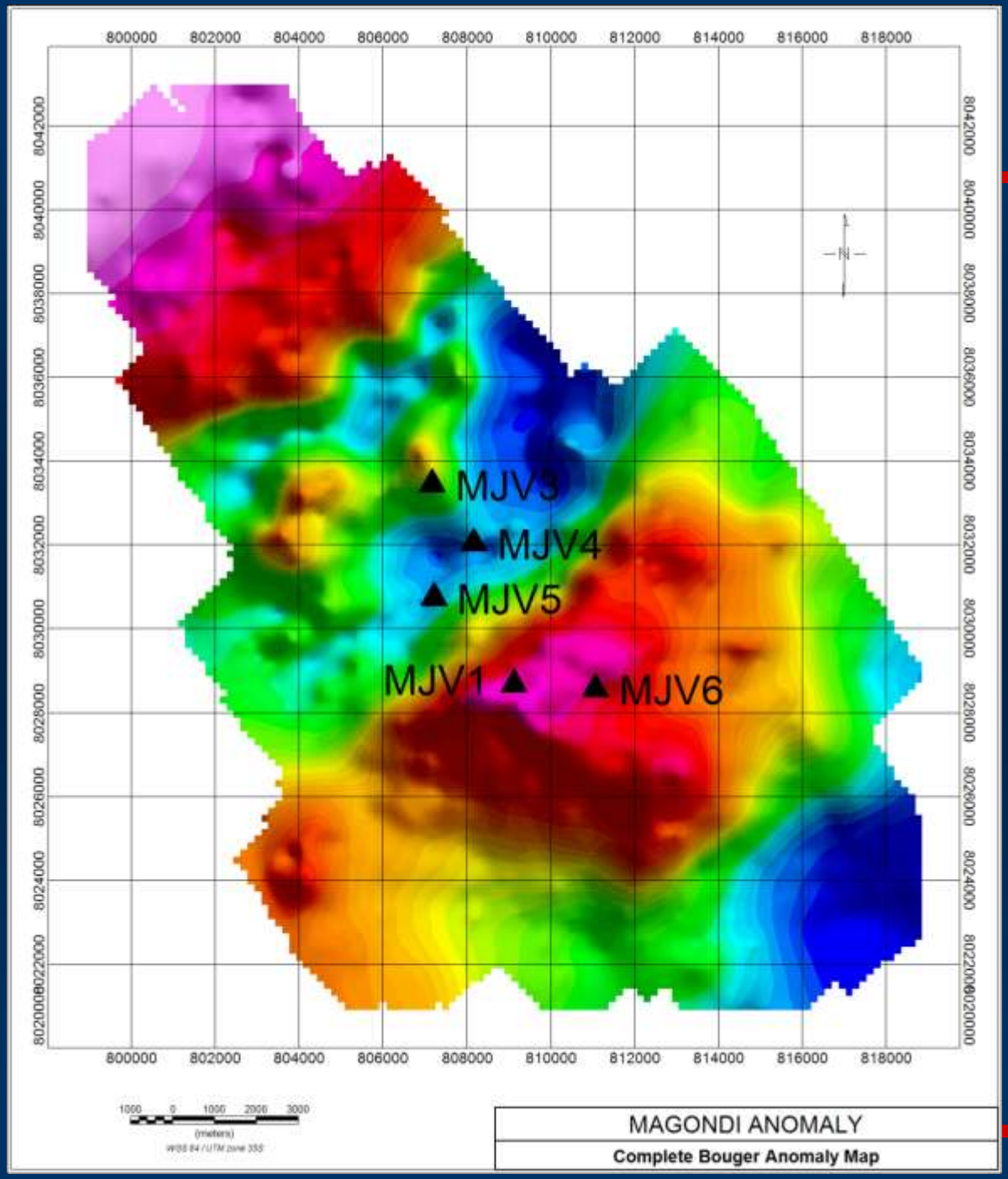
Inducing field: 30000nT

Inc. -85.00 deg dec. -20.00 deg

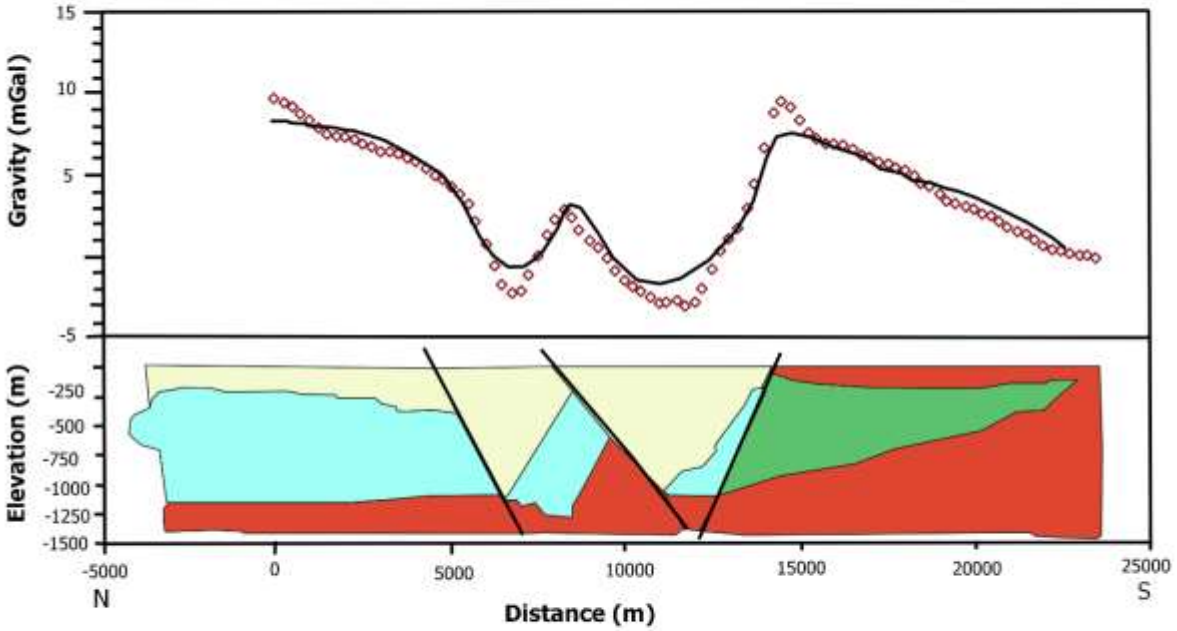

Dipping sheet magnetic model with thick, shallow casuative body
Magnetics (nT)
200
0
-200
-400
-600
-800
Elevation (m)
0
-1000
-2000
-3000
-4000
-5000
-10000
0
10000
20000
30000
40000
50000
60000
Distance (m)
Inducing field: 30000 nT
Inc. -85.00 deg
dec. -20.00 deg


800000
805000
810000
815000
8040000
8035000
8030000
8025000
7.4
6.1
5.1
3.7
3.1
2.8
2.4
2.1
1.7
1.4
1.0
0.4
-0.7
-2.0
-3.0
-3.9
-4.8
-5.7
-6.9
mGal
1000 0 1000 2000 3000
(meters)
MAGONDI MAGNETIC ANOMALY
RESIDUAL COMPLETE BOUGER ANOMALY

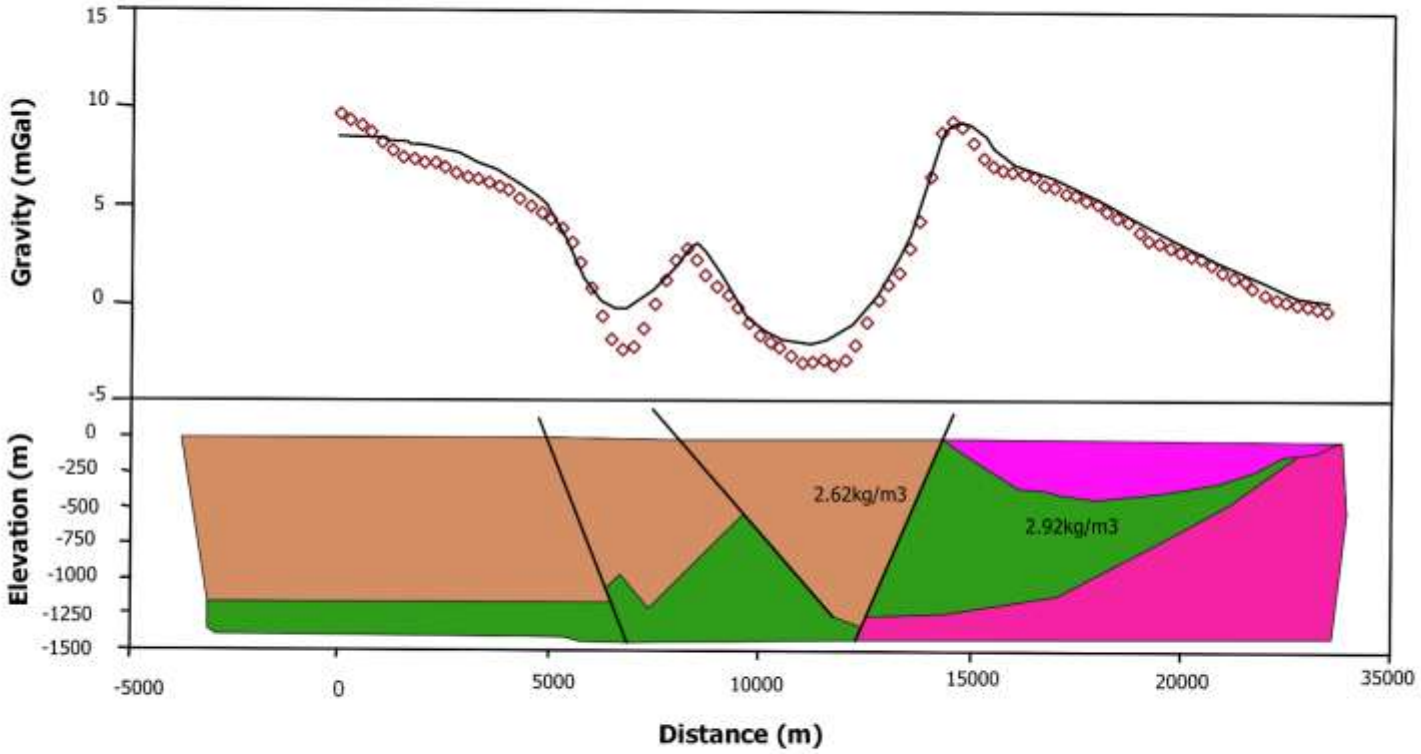

800000
805000
810000
815000
8040000
8035000
8030000
8025000
7.4
6.1
5.1
3.7
3.1
2.8
2.4
2.1
1.7
1.4
1.0
0.4
-0.7
-2.0
-3.0
-3.9
-4.8
-5.7
-6.9
mGal
N
1000 0 1000 2000 3000
(meters)
MAGONDI MAGNETIC ANOMALY
COMPLETE BOUGER ANOMALY

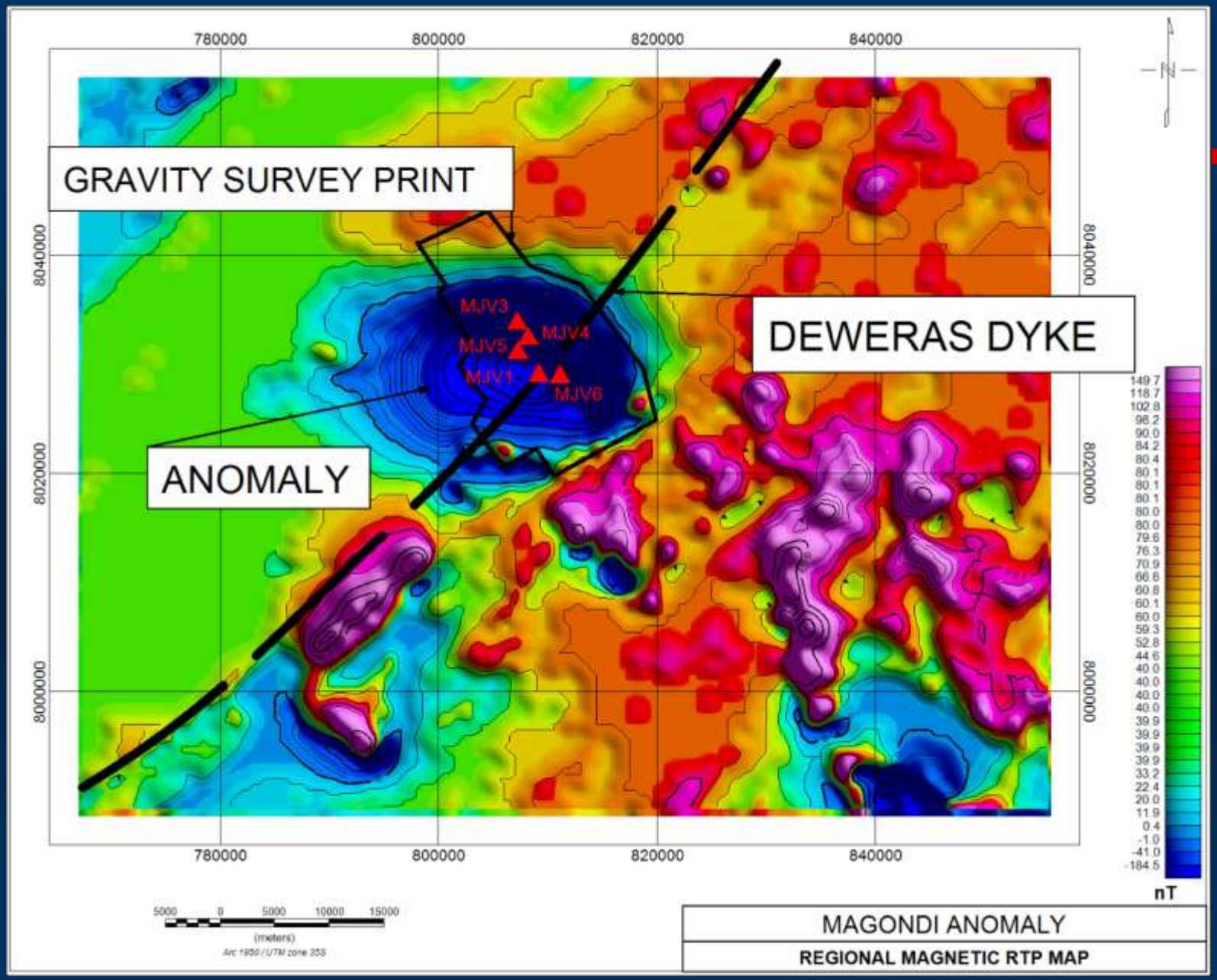

800000
802000
804000
806000
808000
810000
812000
814000
816000
818000
8042000
8040000
8038000
8036000
8034000
8032000
8030000
8028000
8026000
8024000
8022000
8020000
N
MJV3
MJV4
MJV5
MJV1
MJV6
1000 0 1000 2000 3000
(meters)
WGS 84 / UTM zone 35S
MAGONDI ANOMALY
Complete Bouger Anomaly Map

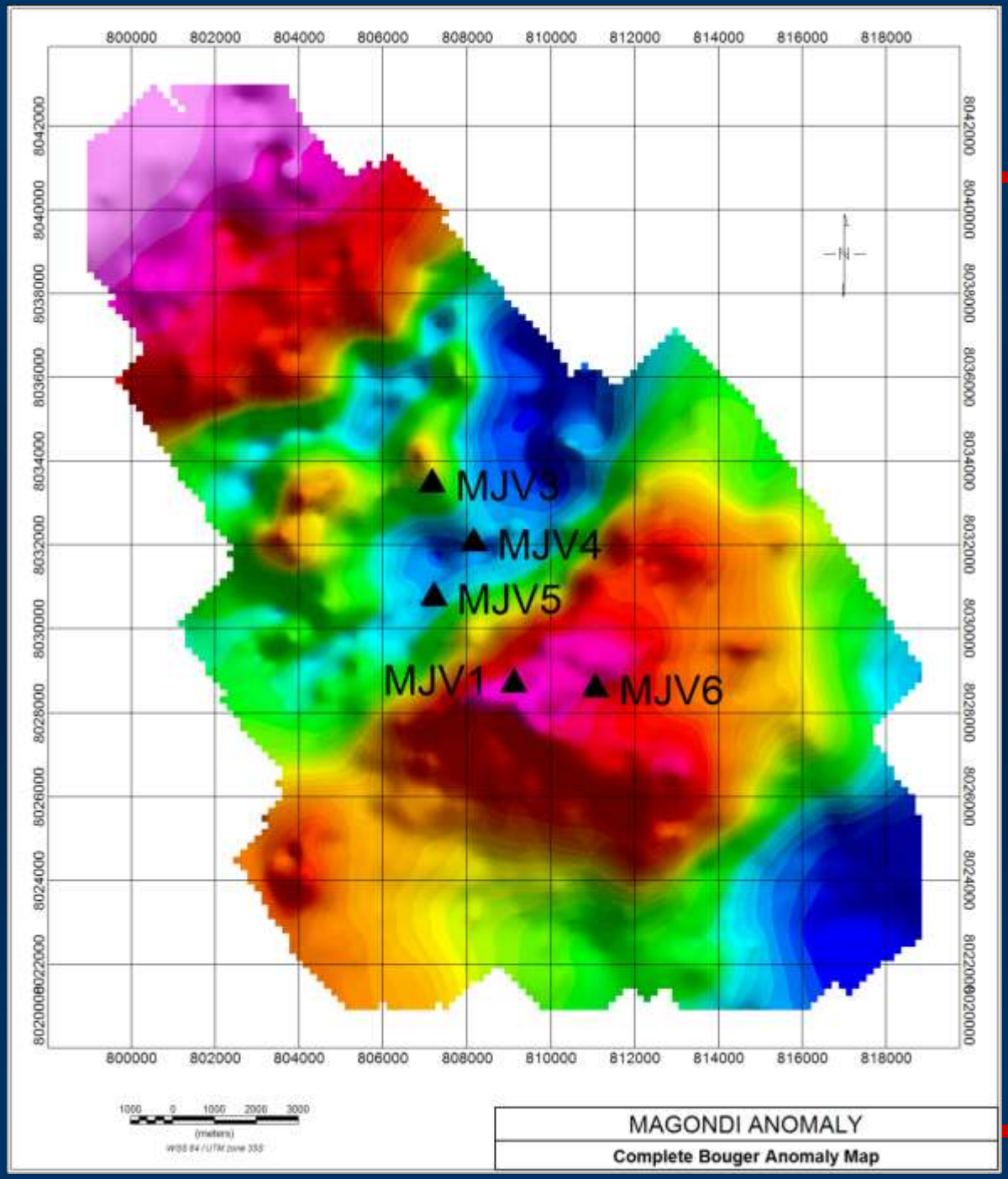
Gravity model



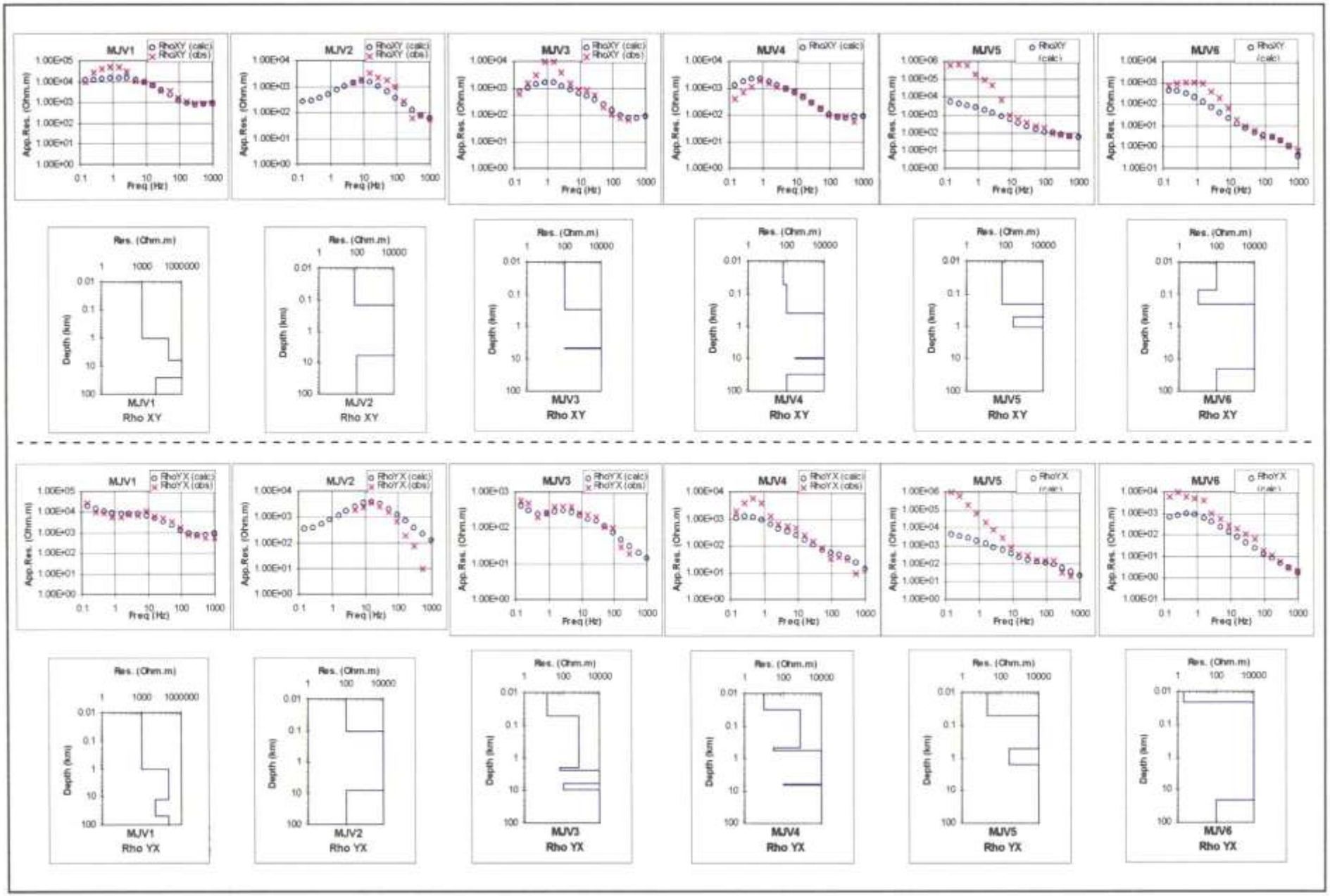
Gravity model

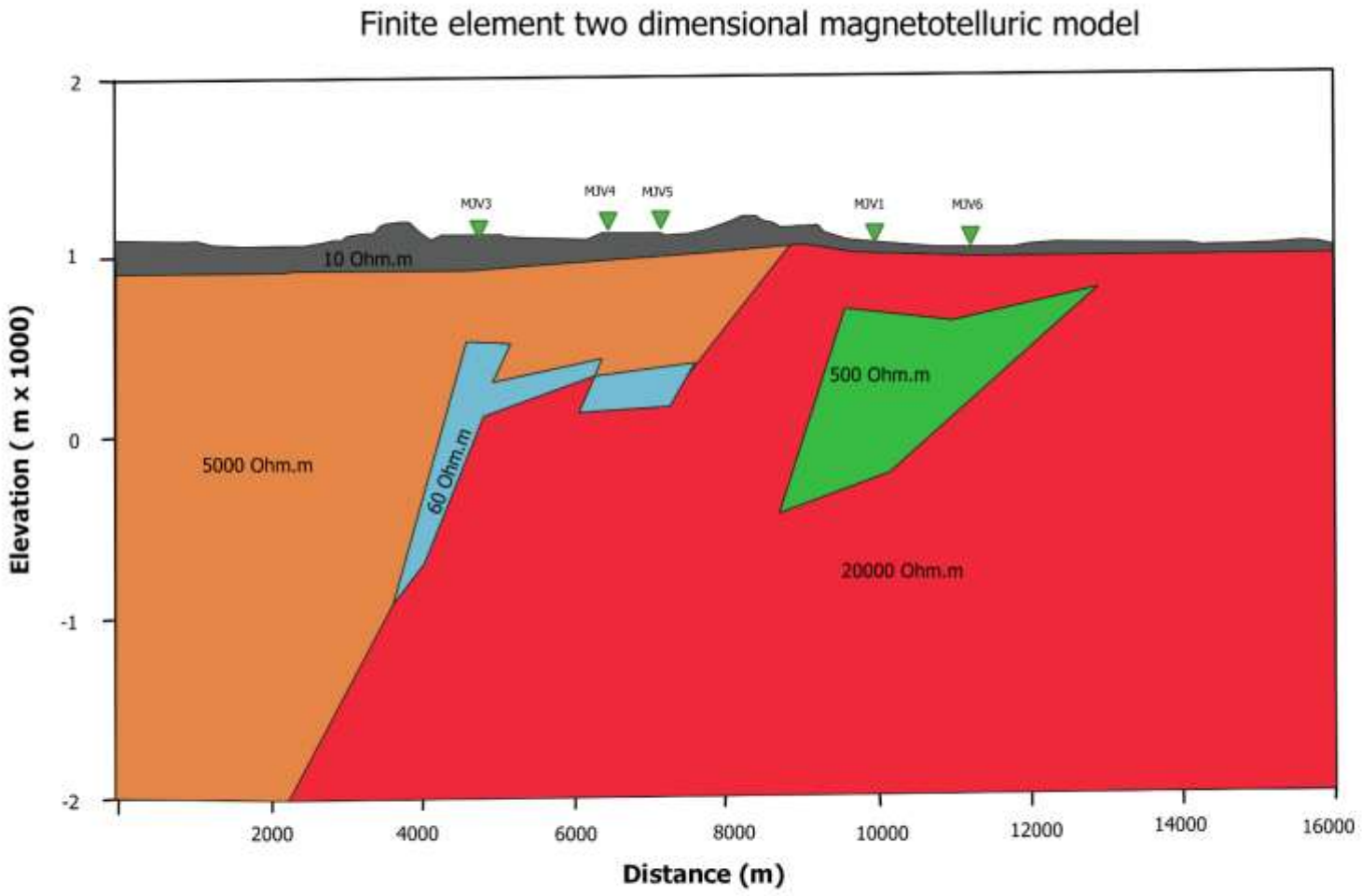



780000
800000
820000
840000
8040000
8020000
8000000
GRAVITY SURVEY PRINT
DEWERAS DYKE
ANOMALY
MJV3
MJV4
MJV5
MJV1
MJV6
149.7
118.7
102.8
98.2
90.0
84.2
80.4
80.1
80.1
80.1
80.0
80.0
79.6
76.3
70.9
66.6
60.8
60.1
60.0
59.3
52.8
44.6
40.0
40.0
40.0
40.0
39.9
39.9
39.9
39.9
33.2
22.4
20.0
11.9
0.4
-1.0
-41.0
-184.5
nT
5000 0 5000 10000 15000
(meters)
Arc 1950 / UTM zone 35S
MAGONDI ANOMALY
REGIONAL MAGNETIC RTP MAP

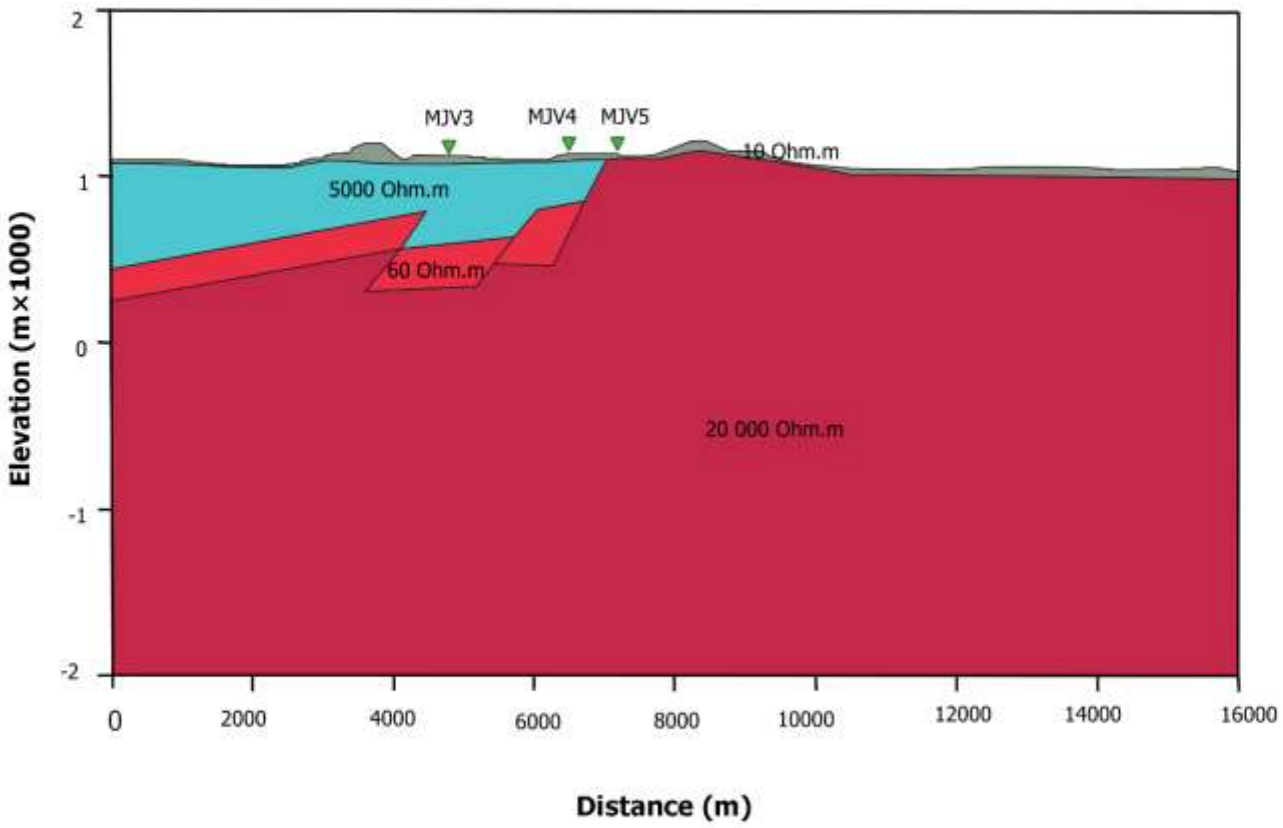

800000
802000
804000
806000
808000
810000
812000
814000
816000
818000
8042000
8040000
8038000
8036000
8034000
8032000
8030000
8028000
8026000
8024000
8022000
8020000
N
MJV3
MJV4
MJV5
MJV1
MJV6
1000 0 1000 2000 3000
(meters)
WGS 84 / UTM zone 35S
MAGONDI ANOMALY
Complete Bouger Anomaly Map

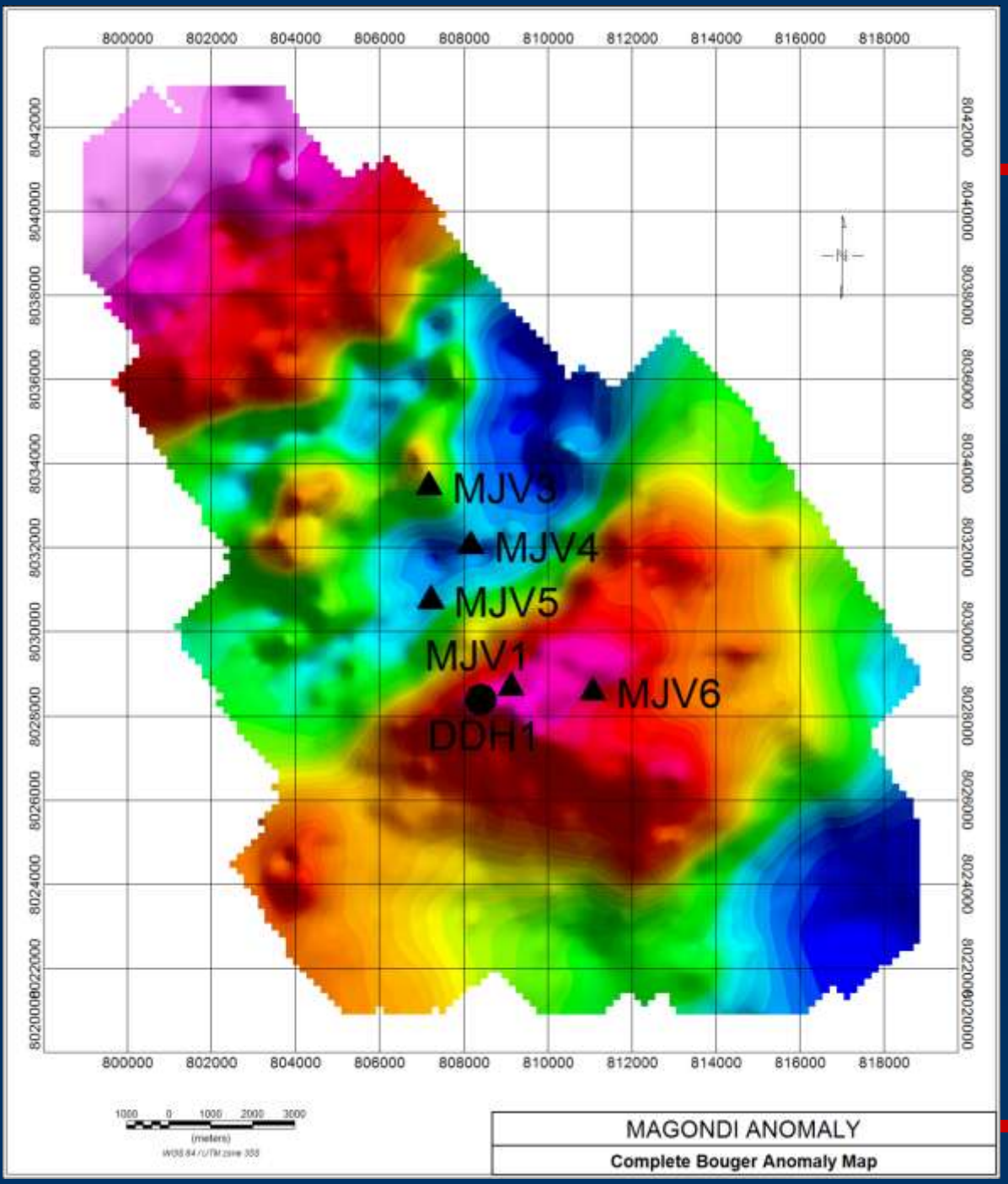
1D MAGNETOTELLURIC MODELS




Finite element two dimensional magnetotelluric model
MJV3
MJV4
MJV5
MJV1
MJV6
10 Ohm.m
5000 Ohm.m
60 Ohm.m
500 Ohm.m
20000 Ohm.m
Elevation (m x 1000)
2
1
0
-1
-2
2000
4000
6000
8000
10000
12000
14000
16000
Distance (m)

Finite element two dimensional magnetotelluric model





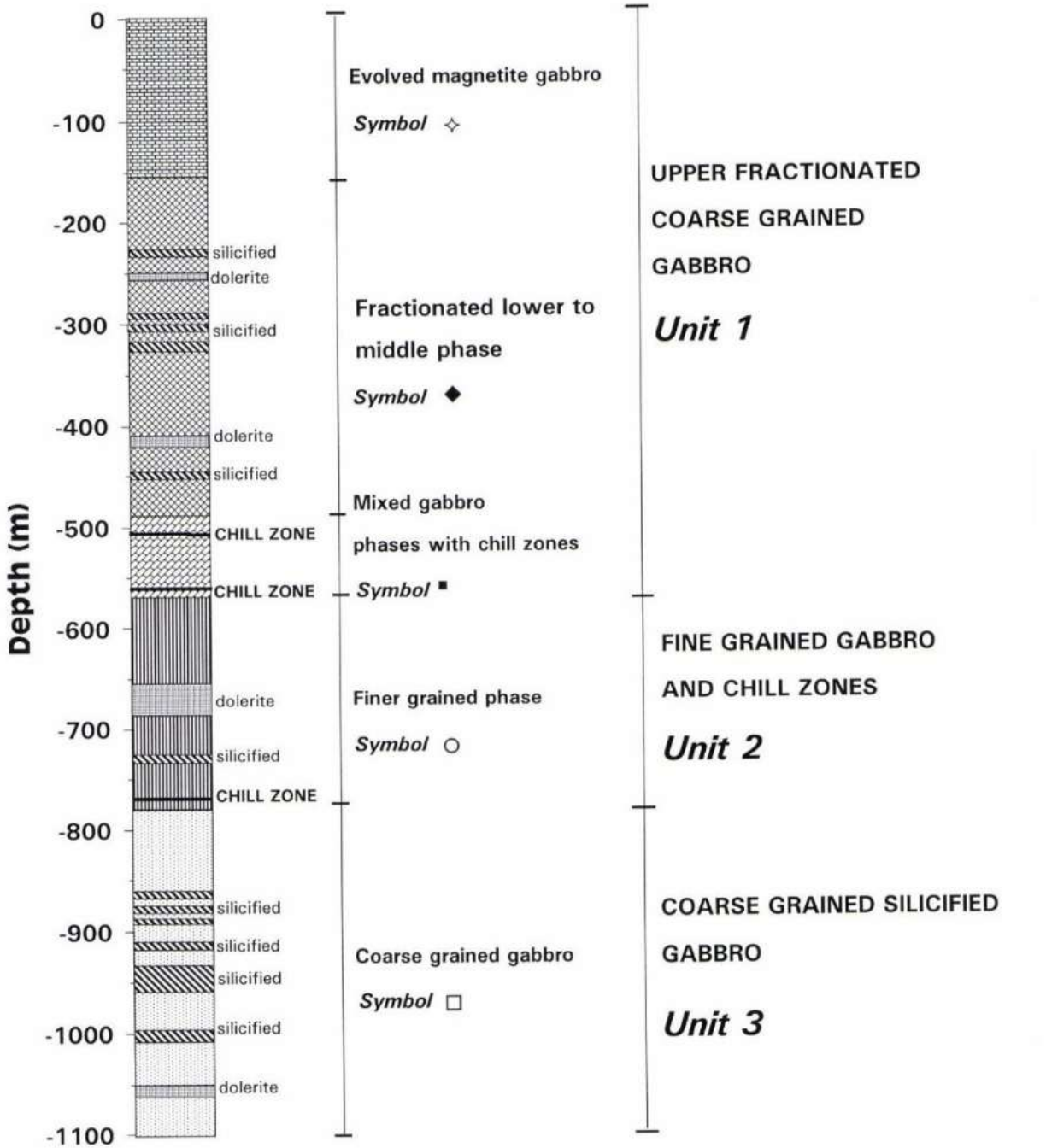
DRILLING

- ✓ TARGETED GRAVITY ANOMALY PEAK
- ✓ COINCIDED WITH CENTRE OF MAGNETIC ANOMALY
- ✓ TARGETED DEPTH 2000M

DRILLING

DEVIATION OF HOLE AT 960M WAS:

- ✓ 27.1M TO THE NORTH OF COLLAR POSITION
- ✓ 57M TO THE EAST OF COLLAR POSITION
- ✓ WAS STOPPED AT 1094.36M HAVING EXPLAINED THE GRAVITY ANOMALY
- ✓ ??? BUT WHAT TNHE MAGNETIC ANOMALY



THE THICK GABBRO SEQUENCE EXPLAINS THE GRAVITY ANOMALY

DOWNHOLE SURVEYS

1ST LOG BY BPB SLIMELINE TO 398M

- ✓ MEASURED WIDTH (3 ARM CALIPER), RADIOACTIVITY (GAMMA RAY), TEMP, DENSITY (DUAL COMPENSATED), MAGNETIC SUSCEPTIBILITY, VERTICALITY
- ❑ 14 TO 53M 2.94g/cc
- ❑ 53 TO 194M 2.97g/cc
- ❑ 194 TO 398M 2.90g/cc

INITIAL GRAVITY MODELS ASSUMED SAME MAGNETIC AND GRAVITYSOURCE

DENSITY > 3.2g/cc

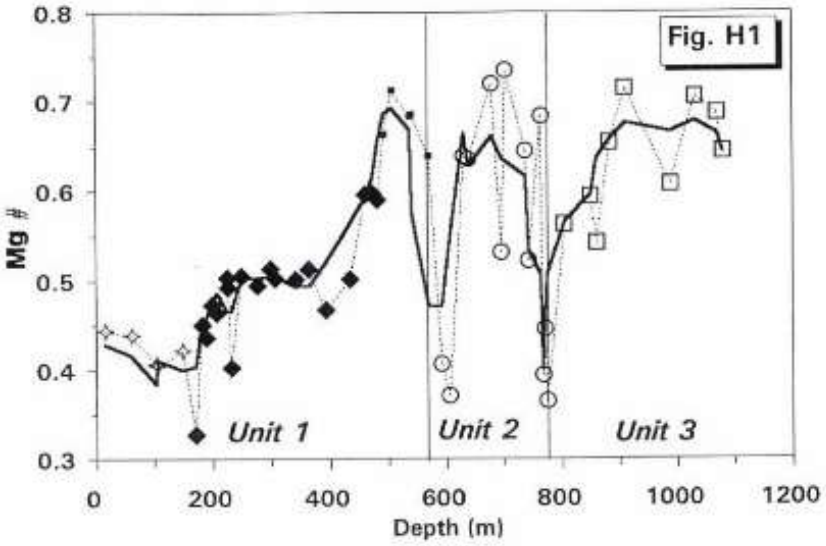
DOWNHOLE SURVEYS

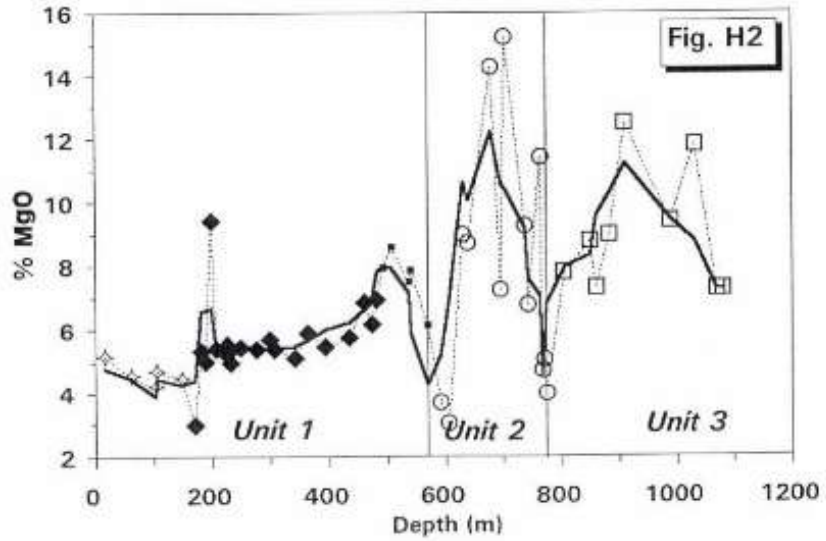
2ND BY GSD FROM 400 TO 960M

- ✓ 3 COMPONENT MAGNETIC LOG
- ✓ MEANT TO ESTIMATE DISTANCE TO TOP OF BODY
- ✓ POLYNOMIAL FITTED TO Z COMPONENT OF MAGNETIC LOG DID NOT REACH INFLECTION POINT
- ✓ DIFFICULT TO DETERMINE MINIMUM DISTANCE TO ITS TURNING POINT
- ✓ TURNING POINT WOULD COINCIDE WITH CENTRE OF MAGNETIC BODY

NATURAL REMANENT MAGNETIZATION (NRM)

- ✓ 20 CORE SPECIMENS TESTED FOR NRM
- ✓ 19 INDICATED LOW INTENSITIES OF VISCOUS REMANENCE WITH INCLINATIONS OF -60°
- ✓ 1 SAMPLE FROM THIN DOLERITE DYKE GAVE A NRM=3250mA/m - INCLINATION 13.3°
- ✓ THIS NRM INTENSITY/INCLINATION ON A LARGE ENOUGH BODY CAN EXPLAIN THE MAG. ANOMALY





Mg# (calculated as atomic Mg/(Mg + Fe^{2+}))

EXPLANATION

The following symbols are used in the Figures:

- ✧ Evolved magnetite gabbro of Unit 1
- ◆ Fractionated lower to middle phase of Unit 1
- • Mixed gabbro phases with chill zones of Unit 1
- ○ Fine grained gabbros and chill zones of Unit 2
- □ Coarse grained and silicified gabbro of Unit 3
- ✞ Deweras Dyke field sample
- ⊠ Field sample of mafic gabbro

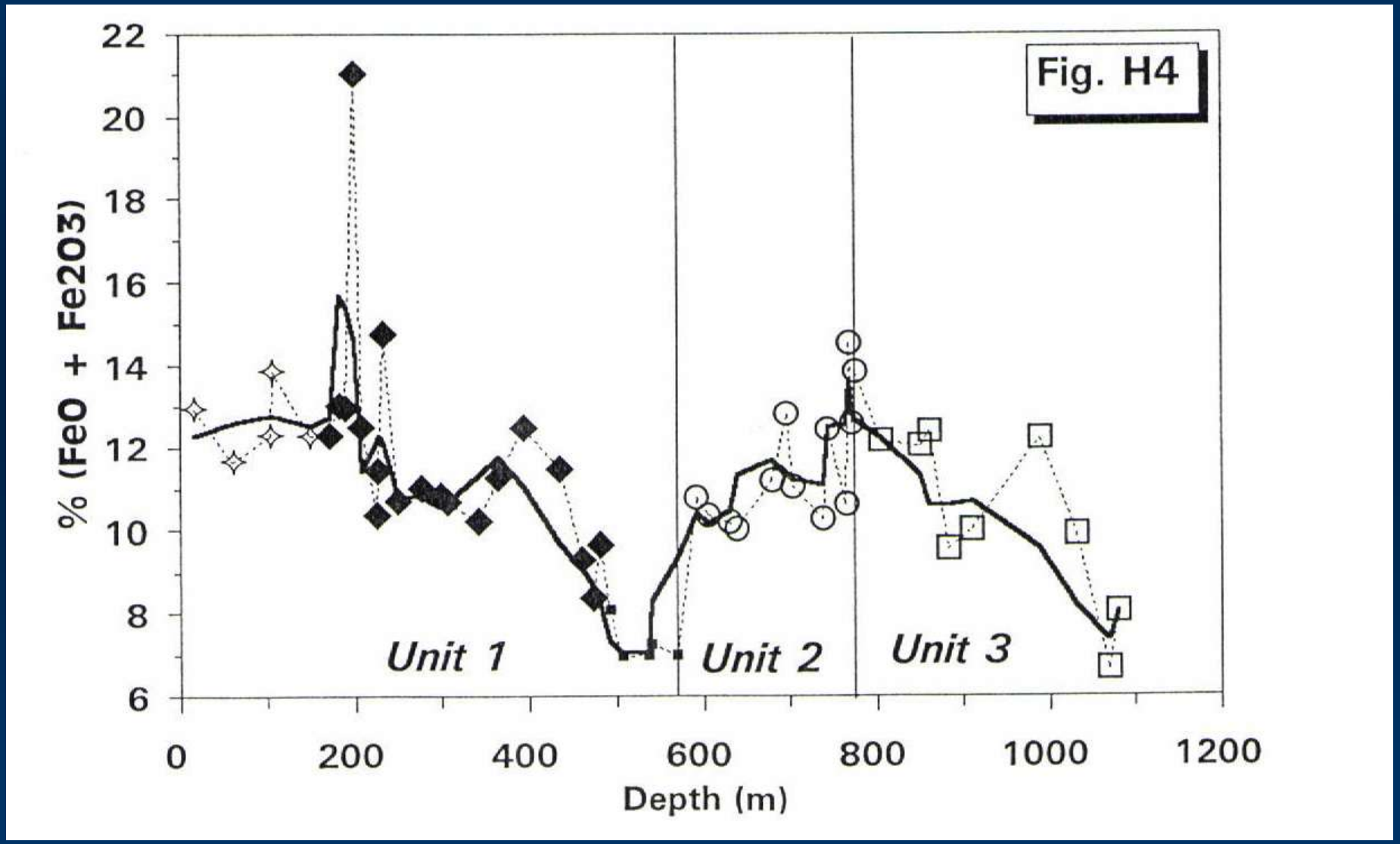
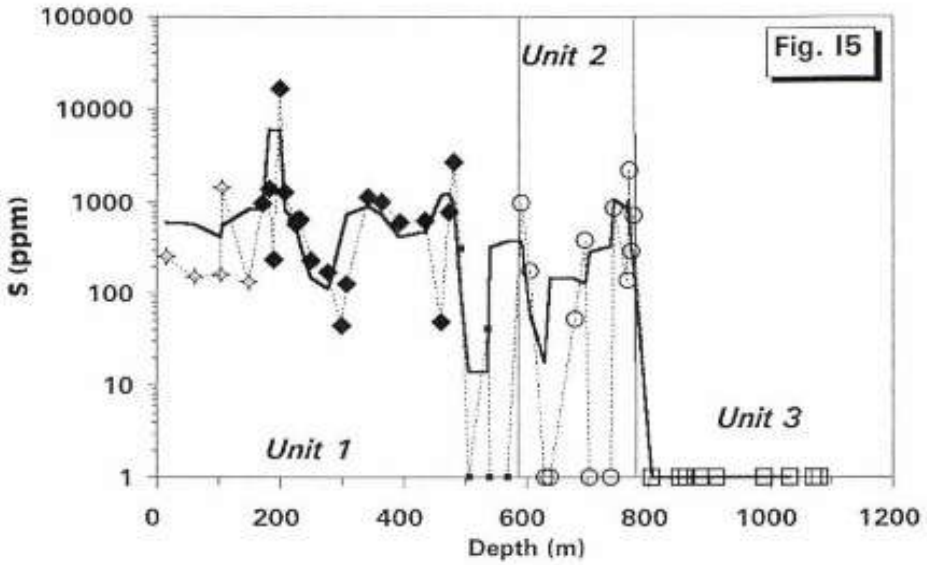
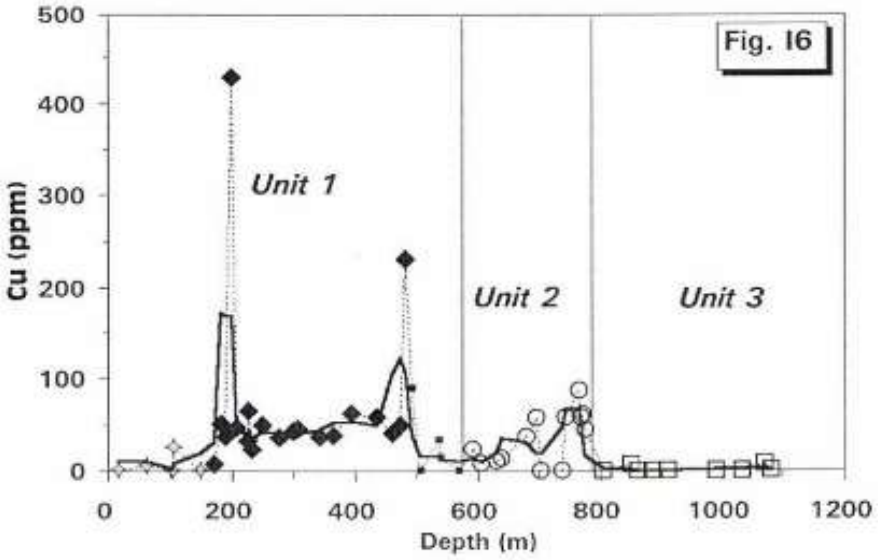


Fig. H4
% (FeO + Fe2O3)
22
20
18
16
14
12
10
8
6
0
200
400
600
800
1000
1200
Depth (m)
Unit 1
Unit 2
Unit 3

MAJOR ELEMENT ANLYSES IN WEIGHT PERCENT [anhydrous]

Sample #	From (m)	To (m)	SiO2	Al2O3	Fe2O3	FeO	MnO	MgO	CaO	Na2O	K2O	TiO2	P2O5	Cr2O3	NiO	TOTAL
DDH1/1	15.85	16.05	47.92	17.72	1.42	11.52	0.15	5.17	9.34	3.01	0.20	3.10	0.18	0.0382	0.0009	99.78
DDH1/5	61.34	61.55	50.24	16.36	1.28	10.37	0.14	4.56	10.76	2.59	0.24	2.87	0.23	0.0399	0.0000	99.67
DDH1/12	103.13	103.31	49.67	16.91	1.35	10.94	0.13	4.20	9.83	2.89	0.21	3.09	0.63	0.0365	0.0003	99.88
DDH1/10	105.57	105.86	48.55	16.38	1.52	12.34	0.15	4.71	9.34	2.46	0.26	3.20	0.26	0.0464	0.0026	99.24
DDH1/14	148.27	148.44	48.50	16.61	1.35	10.93	0.13	4.46	9.83	3.11	0.19	3.28	1.13	0.0422	0.0031	99.57
DDH1/16	171.42	171.61	52.75	16.90	1.35	10.94	0.22	2.98	8.20	3.11	0.22	2.18	0.83	0.0466	0.0011	99.74
DDH1/17	182.60	182.83	50.20	16.00	1.43	11.60	0.16	5.33	9.88	2.43	0.23	1.98	0.47	0.0372	0.0035	99.76
DDH1/18	189.64	189.81	52.05	15.51	1.42	11.53	0.13	5.01	9.54	1.80	0.55	1.91	0.34	0.0356	0.0061	99.84
DDH1/20	199.36	199.58	46.99	15.79	2.31	18.71	0.17	9.41	3.04	1.61	0.09	0.40	0.13	0.0356	0.0162	98.70
DDH1/21	207.18	207.44	51.34	16.33	1.37	11.12	0.15	5.40	9.22	2.38	0.22	1.73	0.38	0.0371	0.0053	99.70
DDH1/27	225.40	225.64	53.84	16.77	1.14	9.23	0.14	5.24	8.92	2.63	0.19	1.32	0.32	0.0395	0.0067	99.78
DDH1/23	226.18	226.37	52.13	16.76	1.26	10.17	0.14	5.53	8.52	3.48	0.31	1.45	0.22	0.0451	0.0089	100.03
DDH1/24	232.16	232.37	50.93	15.30	1.62	13.14	0.16	4.97	8.83	0.63	1.41	2.07	0.23	0.0459	0.0053	99.35
DDH1/25*	234.88	235.07	57.77	16.44	0.85	6.87	0.11	4.35	7.96	4.30	0.68	0.59	0.19	0.0350	0.0074	100.16
DDH1/26	249.78	249.95	53.86	16.39	1.17	9.51	0.16	5.44	8.53	2.93	0.26	1.37	0.20	0.0460	0.0064	99.89
DDH1/28	276.62	276.78	52.72	17.41	1.21	9.79	0.13	5.38	8.30	3.14	0.46	1.36	0.32	0.0427	0.0052	100.29
DDH1/29	298.09	298.35	53.78	16.45	1.19	9.63	0.16	5.70	8.63	3.22	0.38	1.48	0.36	0.0380	0.0058	101.02
DDH1/30	306.75	306.92	53.09	16.04	1.17	9.50	0.18	5.38	8.99	3.48	0.29	1.41	0.40	0.0418	0.0065	99.99
DDH1/33	341.33	341.52	52.41	17.00	1.12	9.09	0.16	5.12	10.94	2.79	0.23	0.89	0.25	0.0439	0.0068	100.05
DDH1/35	363.55	363.74	47.60	19.18	1.24	10.02	0.15	5.91	9.99	3.52	0.22	1.46	0.51	0.0339	0.0059	99.84
DDH1/38	393.05	393.25	51.21	16.83	1.37	11.10	0.16	5.46	9.43	2.05	0.26	1.54	0.17	0.0425	0.0070	99.63
DDH1/42	434.41	434.67	50.67	17.27	1.26	10.20	0.15	5.76	10.53	2.74	0.10	1.28	0.15	0.0472	0.0119	100.17
DDH1/44	460.40	460.66	52.03	19.04	1.02	8.27	0.14	6.84	9.20	2.88	0.15	0.74	0.13	0.0475	0.0084	100.48
DDH1/45	473.22	473.42	53.30	17.74	0.92	7.45	0.13	6.18	11.00	2.57	0.21	0.69	0.13	0.0398	0.0074	100.36
DDH1/46	481.13	481.42	51.02	18.33	1.06	8.60	0.13	6.93	10.47	2.29	0.12	0.84	0.13	0.0323	0.0125	99.97
DDH1/47	492.00	492.28	53.87	16.55	0.89	7.19	0.12	7.92	10.03	2.45	0.25	0.76	0.11	0.0784	0.0153	100.24
DDH1/48	506.14	506.36	53.90	18.97	0.76	6.18	0.10	8.56	7.91	2.81	0.83	0.36	0.06	0.0921	0.0216	100.56
DDH1/49	536.19	536.46	53.26	19.09	0.77	6.20	0.11	7.47	9.41	3.03	0.68	0.44	0.07	0.0462	0.0134	100.58
DDH1/50	539.44	539.71	53.48	20.62	0.79	6.44	0.11	7.83	7.18	3.61	0.23	0.48	0.09	0.0401	0.0136	100.91
DDH1/51	569.19	569.46	54.93	19.10	0.77	6.21	0.10	6.14	9.01	3.21	0.08	0.54	0.06	0.0412	0.0049	100.19
DDH1/53	591.49	591.76	52.17	16.39	1.18	9.59	0.14	3.69	10.47	2.88	0.05	2.23	0.20	0.0499	0.0033	99.05
DDH1/54	605.53	605.77	55.29	16.75	1.14	9.20	0.17	3.04	7.58	3.71	0.13	2.06	0.70	0.0435	0.0011	99.79
DDH1/56	630.35	630.63	48.53	17.02	1.12	9.06	0.17	8.98	12.01	2.07	0.05	0.69	0.06	0.0922	0.0311	99.89
DDH1/57	638.38	638.64	49.28	17.03	1.10	8.92	0.16	8.70	11.97	1.96	0.04	0.69	0.05	0.1011	0.0309	100.02





EXPLANATION

The following symbols are used in the Figures:

- ✧ Evolved magnetite gabbro of Unit 1
- ◆ Fractionated lower to middle phase of Unit 1
- • Mixed gabbro phases with chill zones of Unit 1
- ○ Fine grained gabbros and chill zones of Unit 2
- □ Coarse grained and silicified gabbro of Unit 3
- ✣ Deweras Dyke field sample
- ⊠ Field sample of mafic gabbro

CONCLUSIONS

- ✓ GRAVITY ANOMALY IS CAUSED BY A THICK GABBRO SEQUENCE
- ✓ MAGNETIC ANOMALY ???
- ✓ GRAVITY AND MAGNETIC ANOMALIES NOT CAUSED BY SAME SOURCE
- ✓ MAGNETIC SOURCE IS DEEP, > 1094M