Report

on

BELL BAY

GRAVITY SURVEY

in

Northern Tasmania

for

Delta Materials Pty Ltd
Sydney, NSW.

February 2010

Report number : 0906
Client contact : Alex Boronowski / Ken Morrison

List of Figures

1. Introduction

Atlas Geophysics (Morley, Western Australia) carried out a gravity survey on tenement EL6-2009 near Bell Bay, Tasmania, during January 2010. Ground magnetics were also read. The aim of the survey was to see if useful information about dolerite thickness over the area could be gained from gravity, and possibly magnetic, modelling.

The gravity data was successfully modelled and it is the main concern of this report. The magnetic data is very noisy and not considered useful for the purpose of interpreting dolerite thickness.

2. Survey Design

Figure 1 shows the location of the survey lines. The survey comprised four lines at a bearing of approximately 045 degrees. This orientation was chosen as the best compromise for avoiding areas of very rugged topography, maintaining reasonable coverage of the Delta Materials "Work Program Area", maintaining a reasonable angle to the outcropping dolerite contact in the north, and avoiding the wedge-tailed eagle exclusion zone.

Coordinate and height control was provided by a GPS base station located close to "Pump 2" and "Drill Water Tank" as shown on Figure 1 near the southern portion of line 3. A mobile GPS unit with a radio link to the base station provided the coordinate and height data for the survey lines.

Gravity readings were taken at a nominal interval of 50m along the central two lines at 100m along most of the outer two lines. Magnetic data was read continuously at walking pace using a 0.2 second sample time.

3. Basics of Field Data Correction - Gravity

Good gravity data requires accurate field readings in the order of 1 part in 10 million. Consequently gravity instrumentation is extremely sensitive and data is affected by several factors; latitude, height above a datum, average density of rock above the datum, topography, and local terrain anomalies.

Latitude and height correction are straightforward. Correction for the effect of the thickness of rock above a height datum (eg. sea level) is the Bouguer correction and requires an estimate of the average density of that rock; it ignores topographic variations and assumes an infinite flat slab of constant thickness. The terrain correction compensates for topography and its accuracy is dependent on the accuracy of the digital terrain model used. Any topographic features "on the ground" that are unrepresented in the digital terrain model are the local terrain anomalies.

Generally it is not possible to correct for local terrain anomalies because, by definition, they are unknown and unrepresented in the digital terrain model. In areas of rugged topography, as in some of the Bell Bay survey, these local terrain anomalies may be the cause of localised high or low gravity anomalies in the final corrected gravity data.

4. Processing of Bell Bay Survey Data - Gravity

A rock density of 2.67g/cc was used for applying gravity corrections to the Bell Bay survey data. The estimated in-situ dolerite density is 2.90g/cc [Alex Boronowski e-mail 19/Jan/2010]. There are at present no known accurate density measurements available for the underlying sandstone unit, therefore a typical sandstone density of 2.40g/cc was assumed. A density of 2.67g/cc is then a

reasonable average density for all of the rock occurring between the gravity station and the height datum, assuming an approximately equal proportion of dolerite and sandstone in that zone.

In areas of significant topography the application of a terrain correction will have a significant influence on the final corrected gravity data, and hence on any modelling that results from that data. Without terrain corrections, stations located in valleys (excess material above the station) and hills (lack of material below the station) will both have under-estimated gravity due to the assumption of a flat slab during the Bouguer correction.

In the Bell Bay survey the biggest terrain corrections are on line 4 and the magnitude of these corrections is in the same order as the total magnitude of the dolerite anomaly. Therefore application of a good terrain correction is critical for modelling of the dolerite.

Figure 2 and Figure 3 show stacked profiles of the terrain-corrected gravity on background images of aerial photography and coloured topography respectively.

5. Regional Gravity

Inspection of the gravity profiles reveals that the gravity anomalies remain very high on the northern ends of the lines even though here the data is well off the dolerite outcrop and north of the known dolerite-sandstone contact which lies approximately along the northern boundary of tenement EL6-2009. The high gravity on the northern ends of lines is due to the presence of a major NW-SE trending regional gravity gradient marking the edge of a major regional gravity high lying to the northeast. Figure 4 and Figure 5 show the terrain-corrected detailed gravity superimposed on a coloured image of the regional gravity.

To produce a good model of the dolerite thickness from the new detailed gravity survey it is necessary to first remove the effect of the regional gradient from the detailed data. The distribution of regional gravity stations is not suitable for producing a well-defined regional gradient over most of the detailed-survey area, consequently a large degree of judgement is required to define a suitable regional gradient for removal during modelling.

6. Modelling - Gravity

Figure 6 to Figure 9 show model sections and gravity data profiles for lines 1 to 4 respectively. Horizontal and vertical scales are the same. A separate body with a polygonal cross-section is used for each survey line. The sections are normal to the body strike direction, and the bodies extend into and out of each section half-way to the adjacent survey line. This in effect results in a quasi three-dimensional representation of the whole dolerite body when calculating the modelled gravity anomaly; this produces a better result than modelling one line at a time in isolation of the other lines, while avoiding the need to engage in a full and much more complicated three-dimensional modelling approach.

In Figures 6 to 9 a dolerite density of 2.90g/cc is used with a sandstone background density of 2.40g/cc. Because the survey lines are oriented SW-NE the x-axis on these sections shows the distance in metres from the start of each line at the SW end.

The pink profile shows the estimated regional gradient that is subtracted from the terrain-corrected gravity profile; the resultant anomaly is then used to calculate the shape of the dolerite body. As mentioned above, the regional gradient is not well defined due to the sparse regional gravity station

spacing, therefore these regional gradients have been estimated manually using the available regional data as a general guide.

At the NE ends of the survey lines the regional gradient is reasonably well-determined because we know from outcrop where the dolerite ends. This position is also clearly indicated by slope changes on the gravity profiles for lines 1, 3, and 4; it is not quite so clear-cut looking at the line 2 profile but nonetheless appears to be at about the 1200m position.

As we move nearer the SW ends of the survey lines there is diminishing reliability of the regional gradient defined by the pink line. This is because of both the poor definition of the gradient based on the regional gravity data and, unlike the NE ends of the lines, a lack of a known limit to the dolerite which might otherwise provide another "anchor point" for defining the gradient there. As a consequence the modelled dolerite thickness towards the SW ends of the survey lines will be increasingly influenced by the judgements made in manually defining the regional gradient.

The upper surface of each model body is fixed and defined by the topographic profile along the survey line.

The lower surface of each model body was initially determined using automatic inversion by the modelling software. In most cases this produced a lower surface with some unrealistic and very sharp high and low spikes in order to get the best match with the observed gravity profile. Body vertices at such spike positions were then manually moved to a more acceptable depth in relation to adjacent vertices. The result is a not-so-perfect match at some stations between the observed (black) and calculated (blue) gravity profiles. These poorer matches may well be explained by an imperfect terrain correction and the presence of local terrain anomalies (see Section 3 above).

7. Modelling – Gravity – Effect of a Different Background Density

The in-situ density of the sandstone that forms the background material for the modelling has not been measured and was assumed to be a typical value of 2.4g/cc for the modelling shown in Figures 6 to 9. This equates to a density *contrast* with the dolerite of 0.5g/cc.

Alternative models are shown in Figure 10 to Figure 13. Here the sandstone density has been increased to 2.5g/cc which is still a plausible value and equates to a lower density *contrast* with the dolerite of 0.4g/cc. The lower density contrast requires an increase in dolerite thickness to restore a similar match between observed and modelled gravity profiles. In order to approximately restore the profile match a uniform increase in dolerite thickness of 30% has been applied to these model bodies.

8. Dolerite Thickness Model – In Summary

The dolerite model sections from the modelling with a 2.4g/cc background density (Figures 6 to 9) are shown schematically in plan view on Figure 14. Here the green dolerite cross-sections for each of the respective survey lines have been rotated from vertical to horizontal to provide a simple visual impression of the dolerite model thickness over the survey area. The modelled dolerite thickness at any given position along the survey line (pink dots) can be measured directly from the width, in a NW-SE direction, of the corresponding green polygon using the same scale as the map.

The modelling suggests the base-of-dolerite at the northern ends of the survey lines has an *apparent* dip along the survey line direction averaging about 10° to 15° SW.

Modelled dolerite thickness towards the SW ends of the survey lines becomes less reliable due to uncertainties about the accuracy of the regional gravity gradient removal. Modelled dolerite thickness over the full length of the survey lines also depends on the choice of density for the sandstone unit; if the sandstone density is higher than the 2.4g/cc assumed then the dolerite will be thicker.

9. **Magnetic Data**

Stacked profiles of the ground magnetic data are shown in Figure 15.

The data show considerable "noise" which is likely due to taking magnetic measurements right on the surface of the magnetic source body.

The magnetic data shows good indications of crossing the dolerite-sandstone contact in the north on survey lines 1 and 2 where the magnetic response drops steeply as you head in a NE direction. There are similar but less obvious indications on line 3. Data problems on the northern quarter of line 4 preclude any reliable observations of magnetic change over the contact. For comparison, plotted on each survey line is a green symbol that corresponds to the dolerite contact determined from the gravity modelling.

Overall the magnetic data is not considered to be able to offer any improvement on modelling the dolerite thickness than that already provided by the gravity model. Therefore it is not cost-effective to put further effort into cleaning up and interpreting or modelling the magnetic data.

…Phil Muir
…12th February 2010

Cental portion of image is taken from Delta Materials plot
"Drill Site and Support Infrastructure Map"
Figure 3 in document Work Program Report

250   0   250   500   750

(meters)

GDA94 / Map Grid of Australia zone 55

Detailed Gravity survey lines

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 1

Location Map

| Author: Phil Muir | Date: Feb 2010 |

JOBS\0906_ken_Delta_Minerals\14_final_gravity_REPORT_prep\map_25000.map

491000E 492000E 493000E 494000E 495000E

L1 L2 L3 L4

5448000N

5447000N

L1 L2

L3

L4

5446000N

EL6-2009

491000E 492000E 493000E 494000E 495000E

N

Delta "work area"

250 0 250 500 750

(meters)

GDA94 / Map Grid of Australia zone 55

Detailed Gravity survey lines

Detailed Gravity stacked profiles (either filled or unfilled)
Terrain corrected Bouguer Anomaly
survey line is baselevel = -5 mgal
profile scale 0.2 mgal/mm at 1:25k map scale

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 2

Bouguer Anomaly Stacked Profiles

(terrain corrected gravity)

Author: Phil Muir   Date: Feb 2010

JOBS\0906_ken_Delta_Minerals\14_final_gravity_REPORT_prep\map_25000.map

491000E   492000E   493000E   494000E   495000E

5448000N
5447000N
5446000N

L1   L2   L3   L4

EL6-2009

Topography
AHD (m)

328
275
236
201
167
139
116
97
78
60
46
37
13
1

Delta "work area"

• Detailed Gravity stations

Detailed Gravity survey lines

Detailed Gravity stacked profiles (either filled or unfilled)
Terrain corrected Bouguer Anomaly
survey line is baselevel = -5 mgal
profile scale 0.2 mgal/mm at 1:25k map scale

250   0   250   500   750

(meters)
GDA94 / Map Grid of Australia zone 55

JOBS\0906_ken_Delta_Minerals\14_final_gravity_REPORT_prep\map_25000.map

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 3

Bouguer Anomaly Stacked Profiles

on coloured topography

| Author: Phil Muir | Date: Feb 2010 |

7.4		
5.3		
3.8		
2.7		
1.8		
1.0		
0.3		
-0.2		
-0.7		
-1.4		
-2.0		
-2.9		
-4.1		
-6.8		

Regional Gravity
Boug Anomaly

Regional Gravity stations

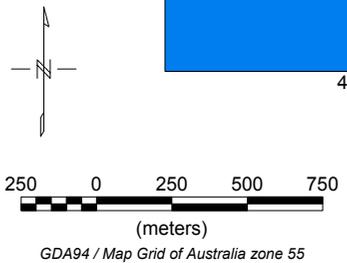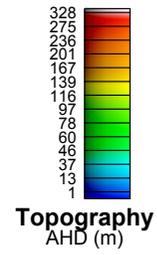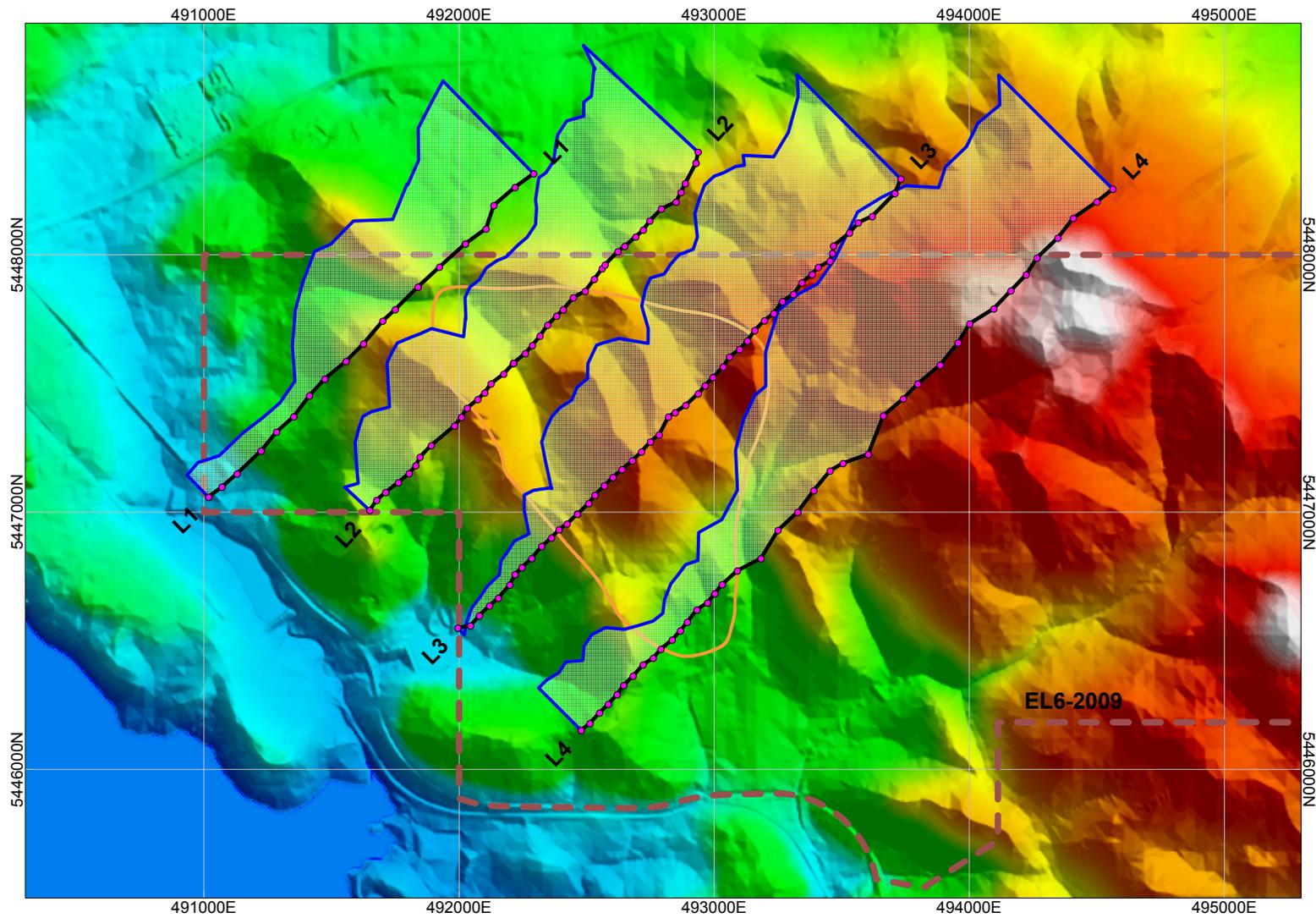Detailed Gravity stations

Detailed Gravity survey lines

Detailed Gravity stacked profiles (either filled or unfilled)
Terrain corrected Bouguer Anomaly
survey line is baselevel = -5 mgal
profile scale 0.2 mgal/mm at 1:25k map scale

Delta "work area"

250 0 250 500 750

(meters)
GDA94 / Map Grid of Australia zone 55

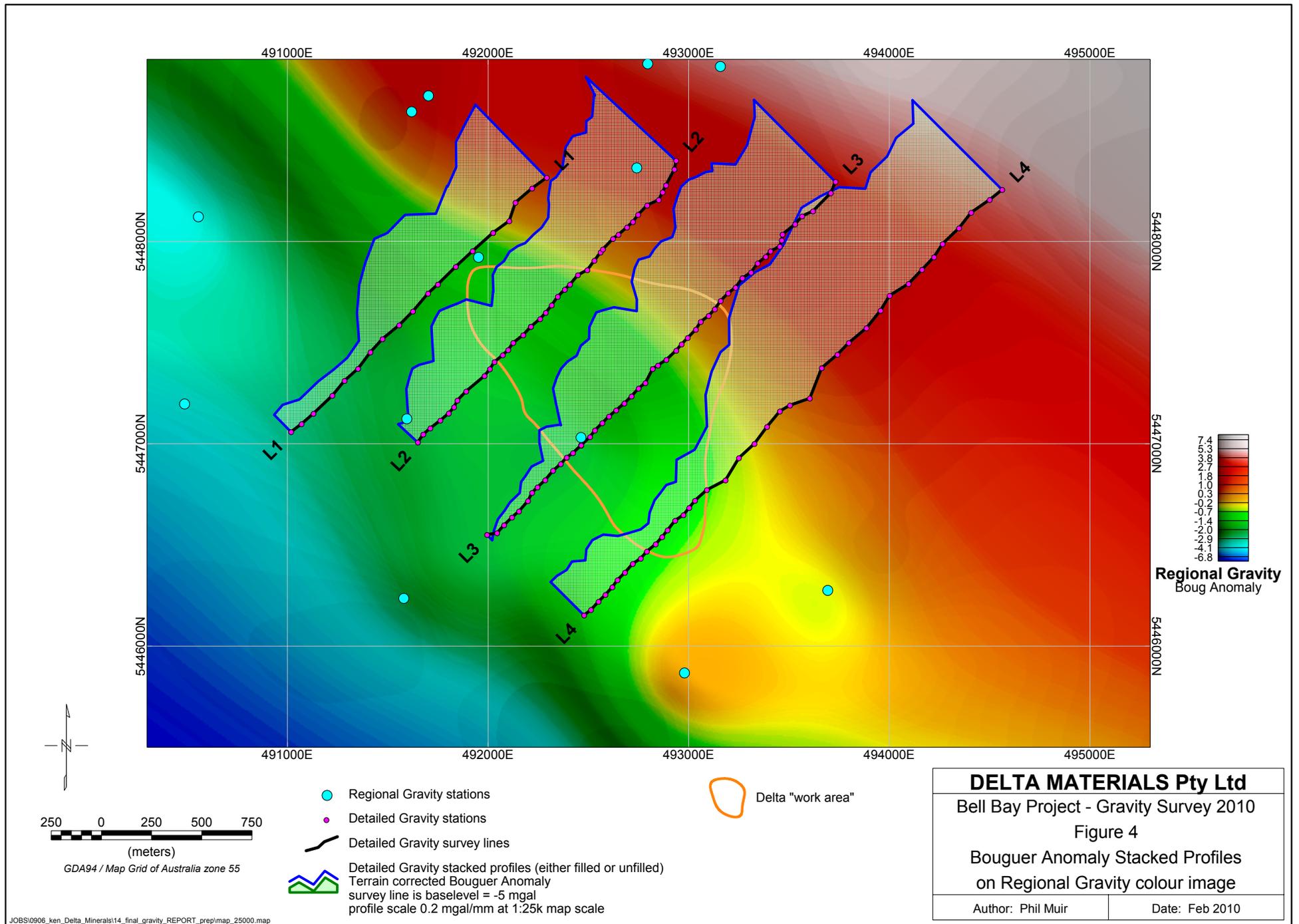JOBS\0906_ken_Delta_Minerals\14_final_gravity_REPORT_prep\map_25000.map

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 4

Bouguer Anomaly Stacked Profiles

on Regional Gravity colour image

Author: Phil Muir	Date: Feb 2010

Detailed Gravity
Boug Anomaly

-0.3
-0.6
-0.8
-1.0
-1.5
-1.9
-2.1
-2.4
-2.6
-3.0
-3.4
-3.8
-4.2
-4.5

Regional Gravity
Boug Anomaly

7.4
5.3
3.8
2.7
1.8
1.0
0.3
-0.2
-0.7
-1.4
-2.0
-2.9
-4.1
-6.8

○ Regional Gravity stations

• Detailed Gravity stations

Delta "work area"

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 5

Bouguer Anomaly colour image

on Regional Gravity colour image

| Author: Phil Muir | Date: Feb 2010 |

250   0   250   500   750

(meters)

GDA94 / Map Grid of Australia zone 55

JOBS\0906_ken_Delta_Minerals\14_final_gravity_REPORT_prep\map_25000.map

Bouguer Anomaly (mgal)

-0.0

-2.0

-4.0

0 500 1000 1500 2000

Relative Level (-AHD; metres)

-250

dolerite : 2.90 g/cc model density

-0

250 background : 2.40 g/cc

0 500 1000 1500 2000

Distance along line from start at SW end

Bouguer Anomaly - modelled

Bouguer Anomaly - survey data (terrain corrected)

Regional Gravity base used for modelling

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 6

Gravity Model Section - Line 1

(background density 2.4 g/cc)

Author: Phil Muir   Date: Feb 2010

Bouguer Anomaly (mgal)

-0.0

-2.0

-4.0

0   500   1000   1500   2000

Relative Level (-AHD; metres)

-250

dolerite : 2.90 g/cc model density

-0

250   background : 2.40 g/cc

0   500   1000   1500   2000
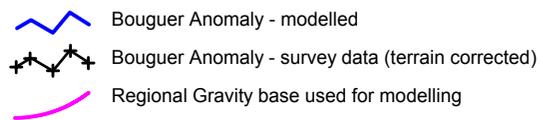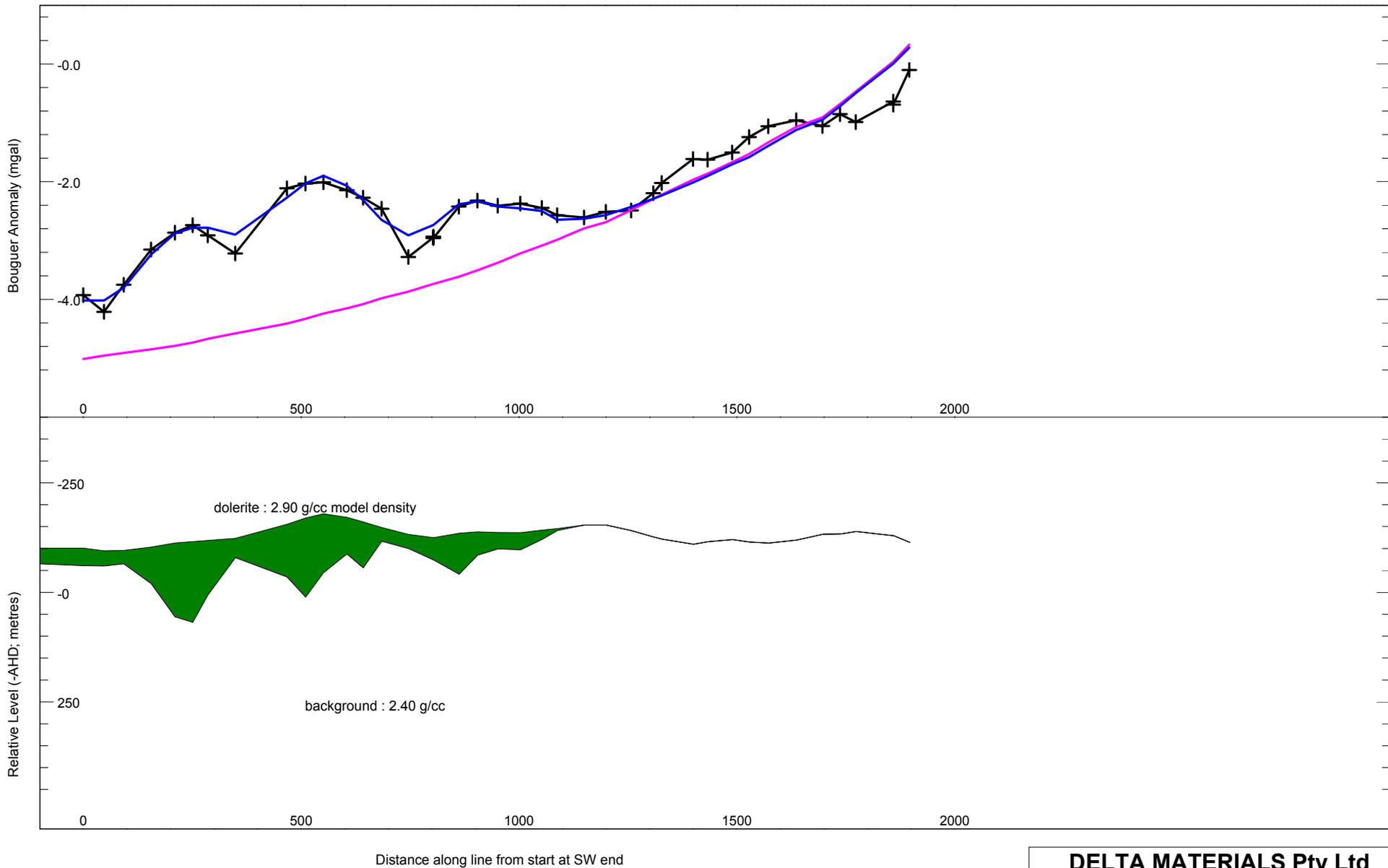
Distance along line from start at SW end

Bouguer Anomaly - modelled

Bouguer Anomaly - survey data (terrain corrected)

Regional Gravity base used for modelling

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 7

Gravity Model Section - Line 2

(background density 2.4 g/cc)

| Author: Phil Muir | Date: Feb 2010 |

Bouguer Anomaly (mgal)

-0.0
-2.0
-4.0

0   500   1000   1500   2000   2500

Relative Level (-AHD; metres)

-250
-0
250

dolerite : 2.90 g/cc model density

background : 2.40 g/cc

0   500   1000   1500   2000   2500
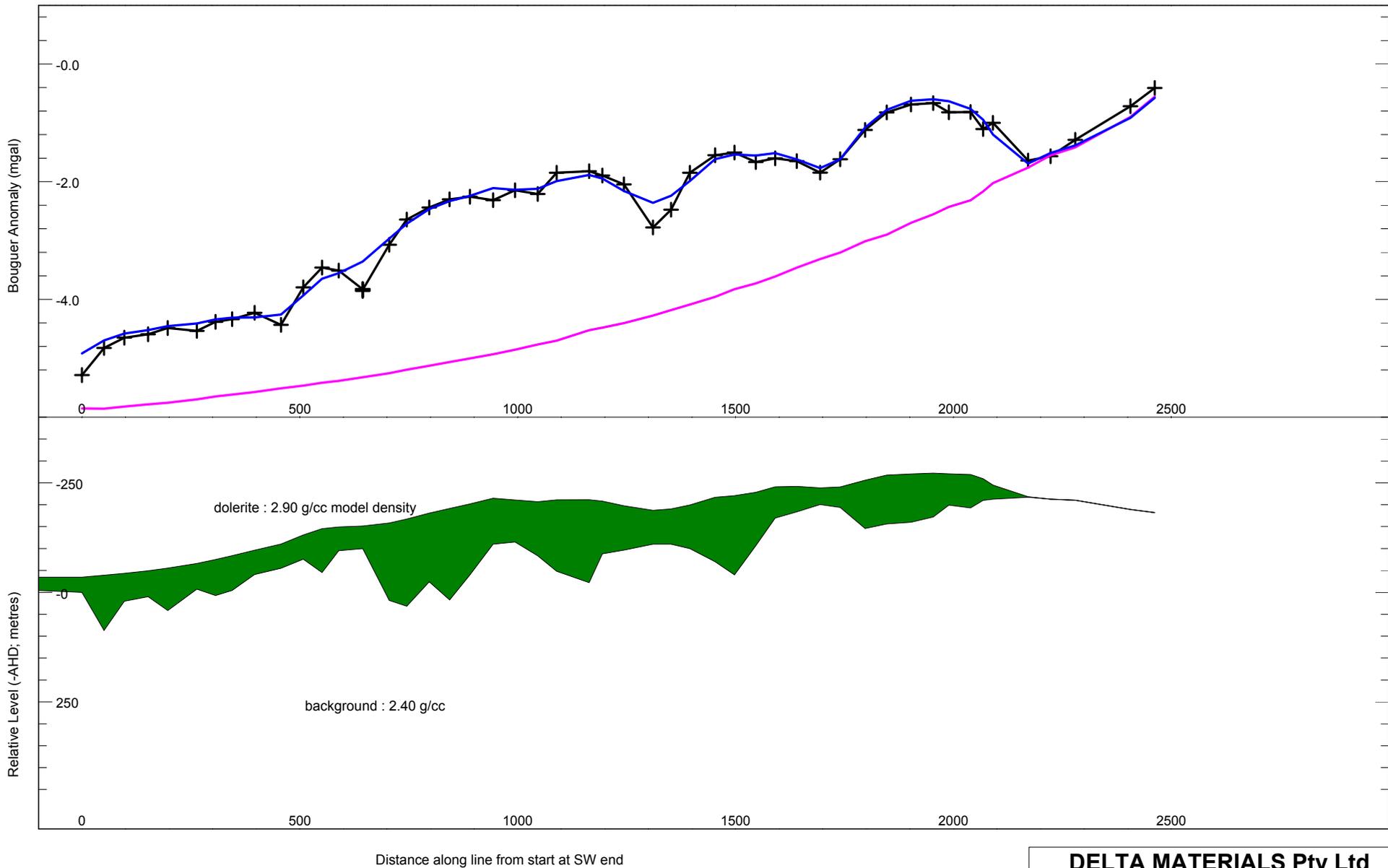
Distance along line from start at SW end

Bouguer Anomaly - modelled

Bouguer Anomaly - survey data (terrain corrected)

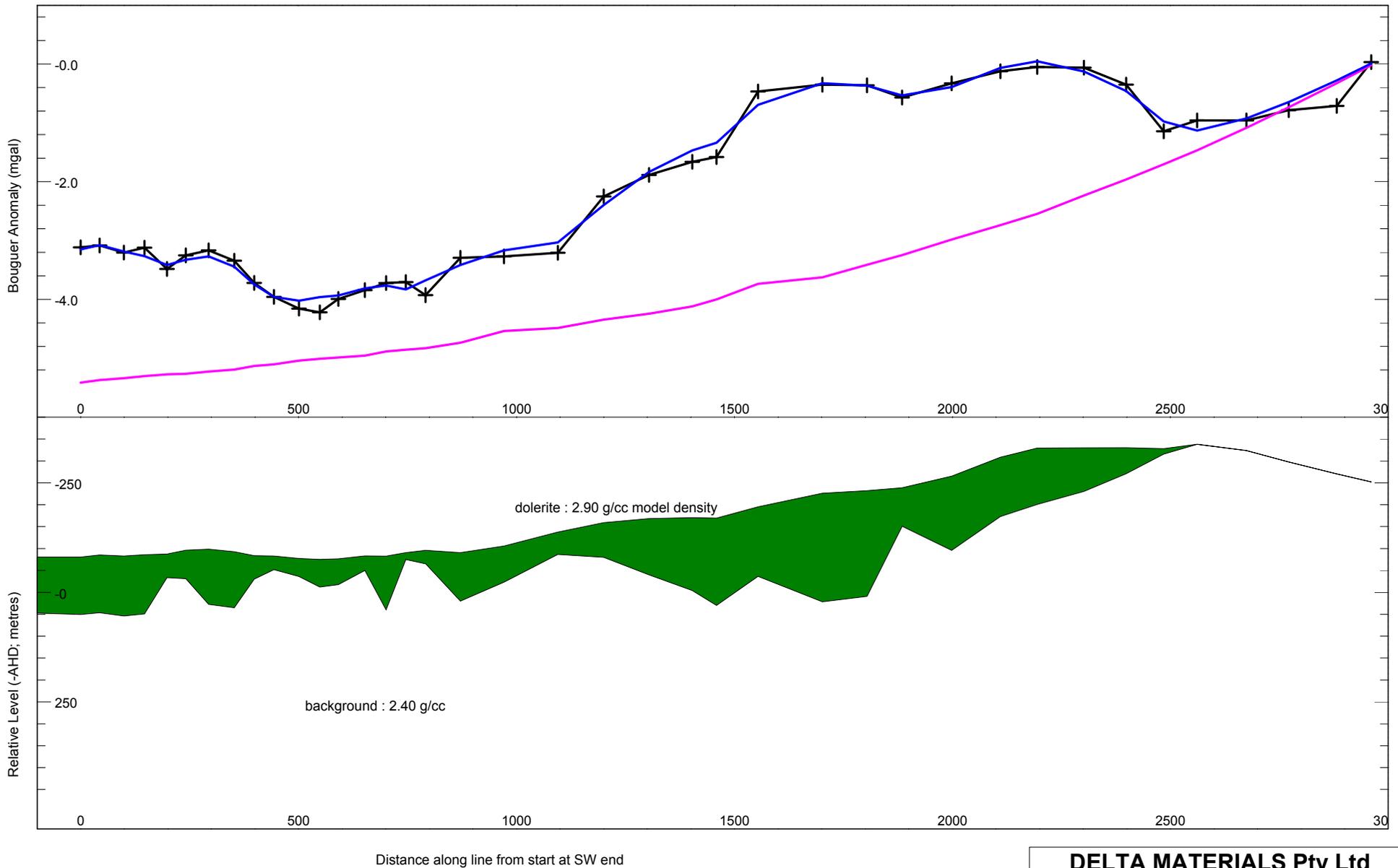Regional Gravity base used for modelling

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 8

Gravity Model Section - Line 3

(background density 2.4 g/cc)

| Author: Phil Muir | Date: Feb 2010 |

Bouguer Anomaly (mgal)

-0.0
-2.0
-4.0

0   500   1000   1500   2000   2500   30

Relative Level (-AHD; metres)

-250
-0
250

dolerite : 2.90 g/cc model density

background : 2.40 g/cc

0   500   1000   1500   2000   2500   30

Distance along line from start at SW end

Bouguer Anomaly - modelled
Bouguer Anomaly - survey data (terrain corrected)
Regional Gravity base used for modelling

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 9

Gravity Model Section - Line 4

(background density 2.4 g/cc)

| Author: Phil Muir | Date: Feb 2010 |

Bouguer Anomaly (mgal)

-0.0

-2.0

-4.0

0   500   1000   1500   2000

Relative Level (-AHD; metres)

-250

dolerite : 2.90 g/cc model density

-0

250   background : 2.50 g/cc

0   500   1000   1500   2000

Distance along line from start at SW end
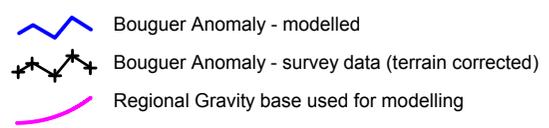
Bouguer Anomaly - modelled

Bouguer Anomaly - survey data (terrain corrected)

Regional Gravity base used for modelling
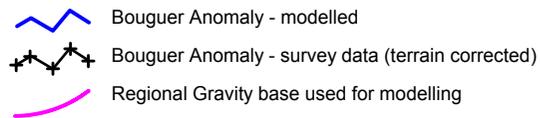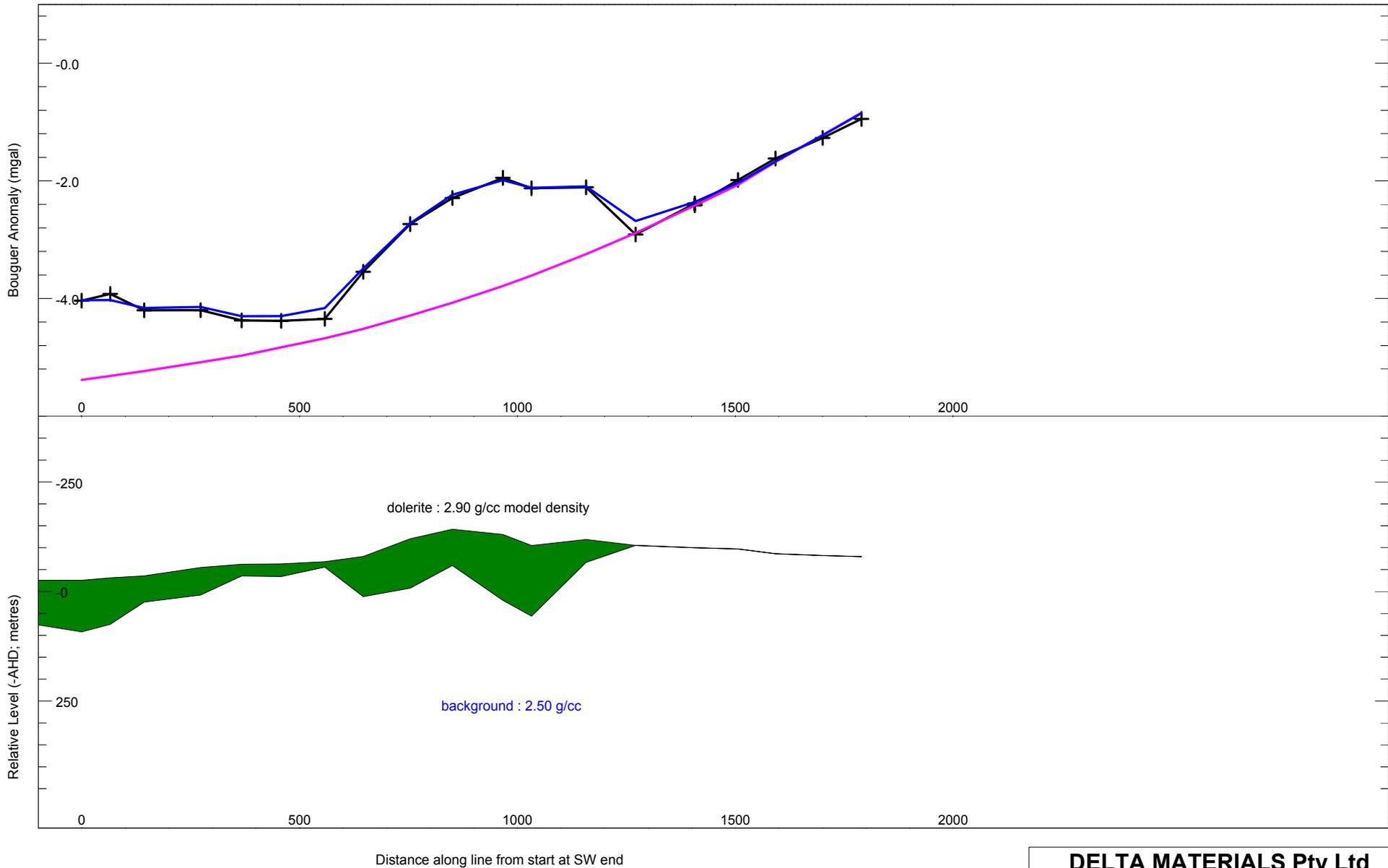
DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 10

Gravity Model Section - Line 1

(background density 2.5 g/cc)

Author: Phil Muir   Date: Feb 2010

Bouguer Anomaly (mgal)

-0.0

-2.0

-4.0

0   500   1000   1500   2000

Relative Level (-AHD; metres)

-250

dolerite : 2.90 g/cc model density

-0

250

background : 2.50 g/cc

0   500   1000   1500   2000
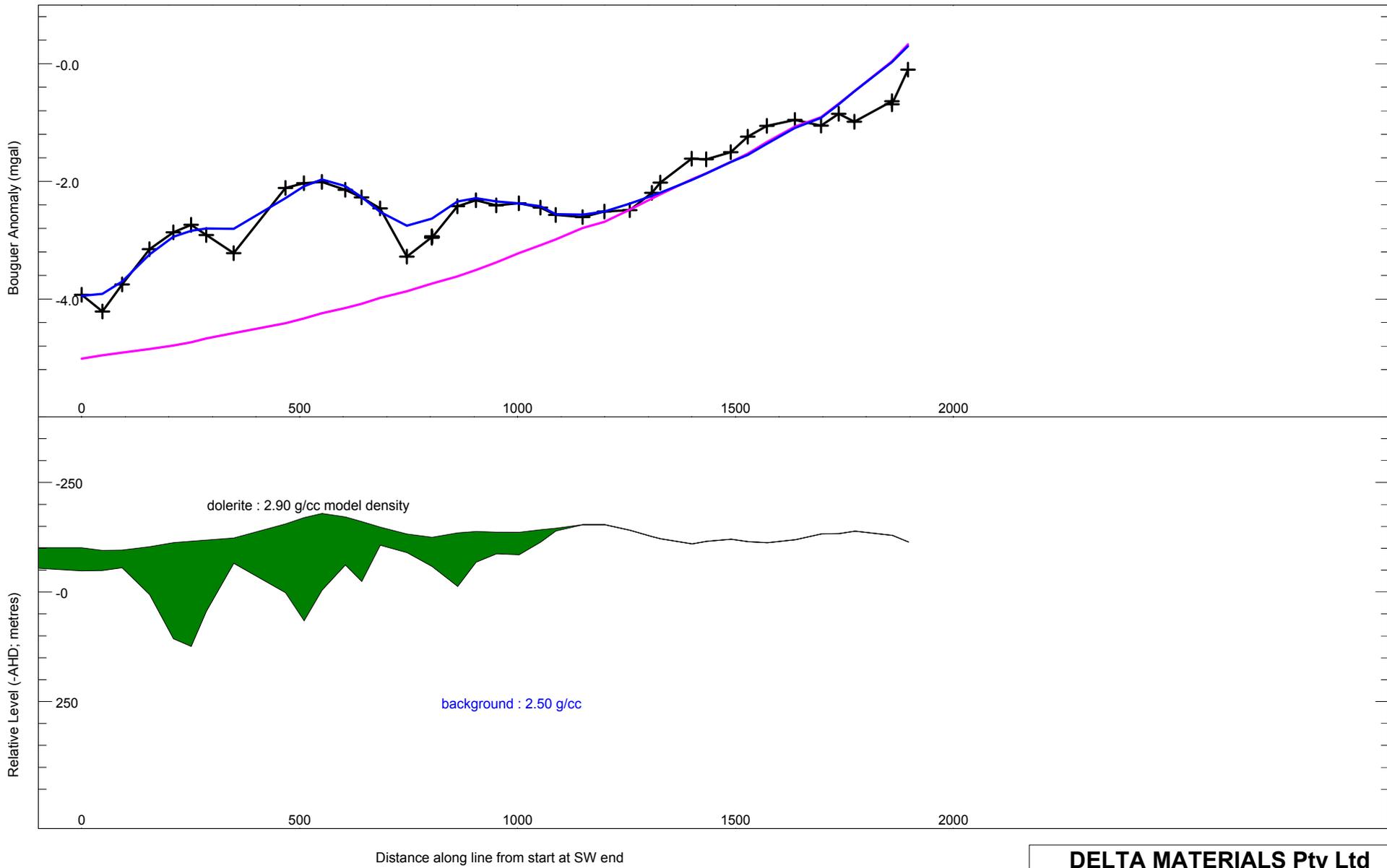
Distance along line from start at SW end

Bouguer Anomaly - modelled

Bouguer Anomaly - survey data (terrain corrected)

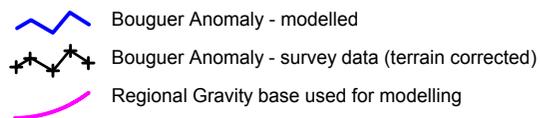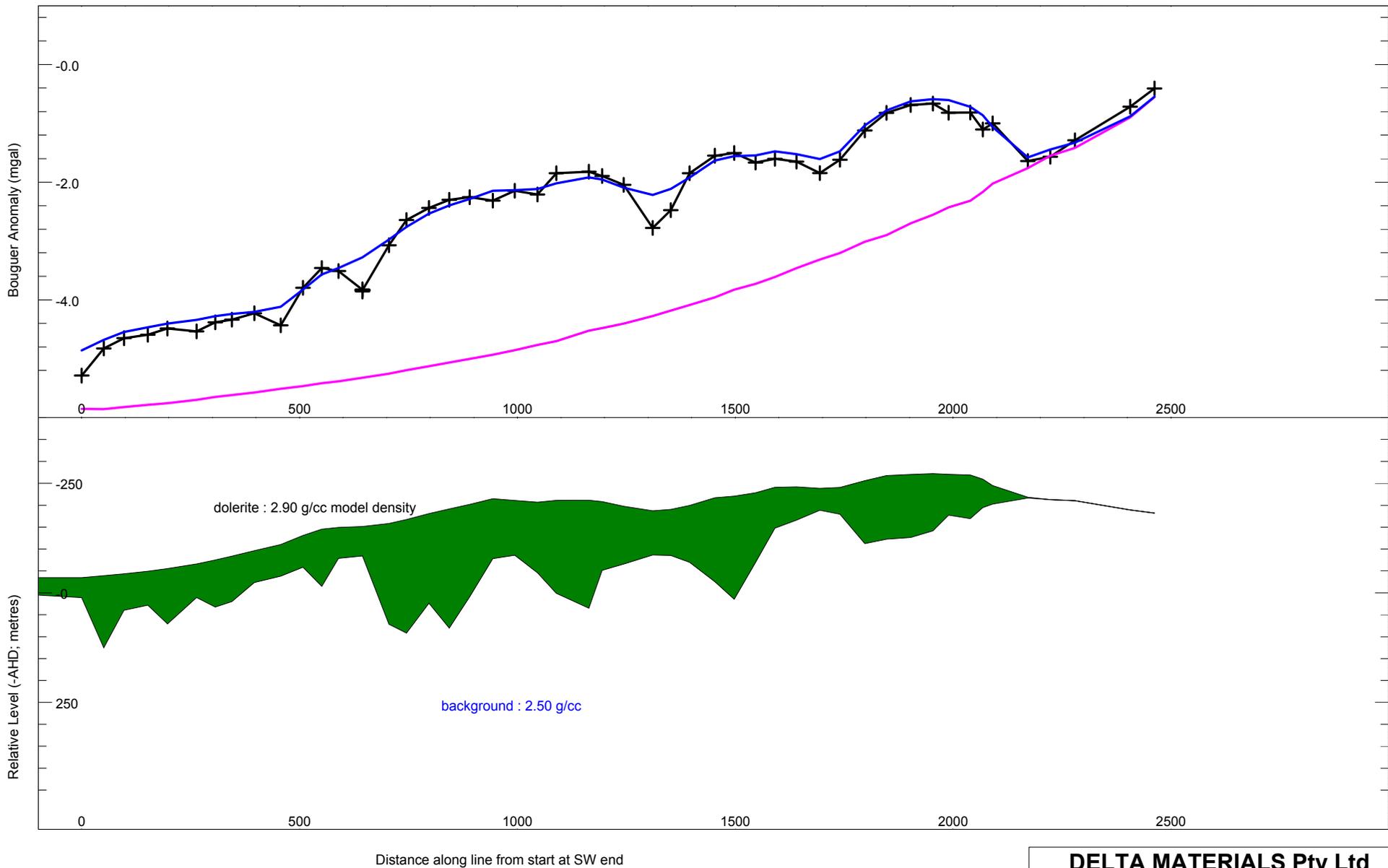Regional Gravity base used for modelling

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 11

Gravity Model Section - Line 2

(background density 2.5 g/cc)

Author: Phil Muir   Date: Feb 2010

Bouguer Anomaly (mgal)

-0.0

-2.0

-4.0

0   500   1000   1500   2000   2500

Relative Level (-AHD; metres)

-250

dolerite : 2.90 g/cc model density

0

250

background : 2.50 g/cc

0   500   1000   1500   2000   2500

Distance along line from start at SW end

Bouguer Anomaly - modelled

Bouguer Anomaly - survey data (terrain corrected)
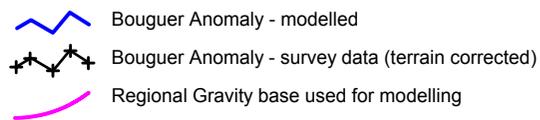
Regional Gravity base used for modelling

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 12

Gravity Model Section - Line 3

(background density 2.5 g/cc)

Author: Phil Muir

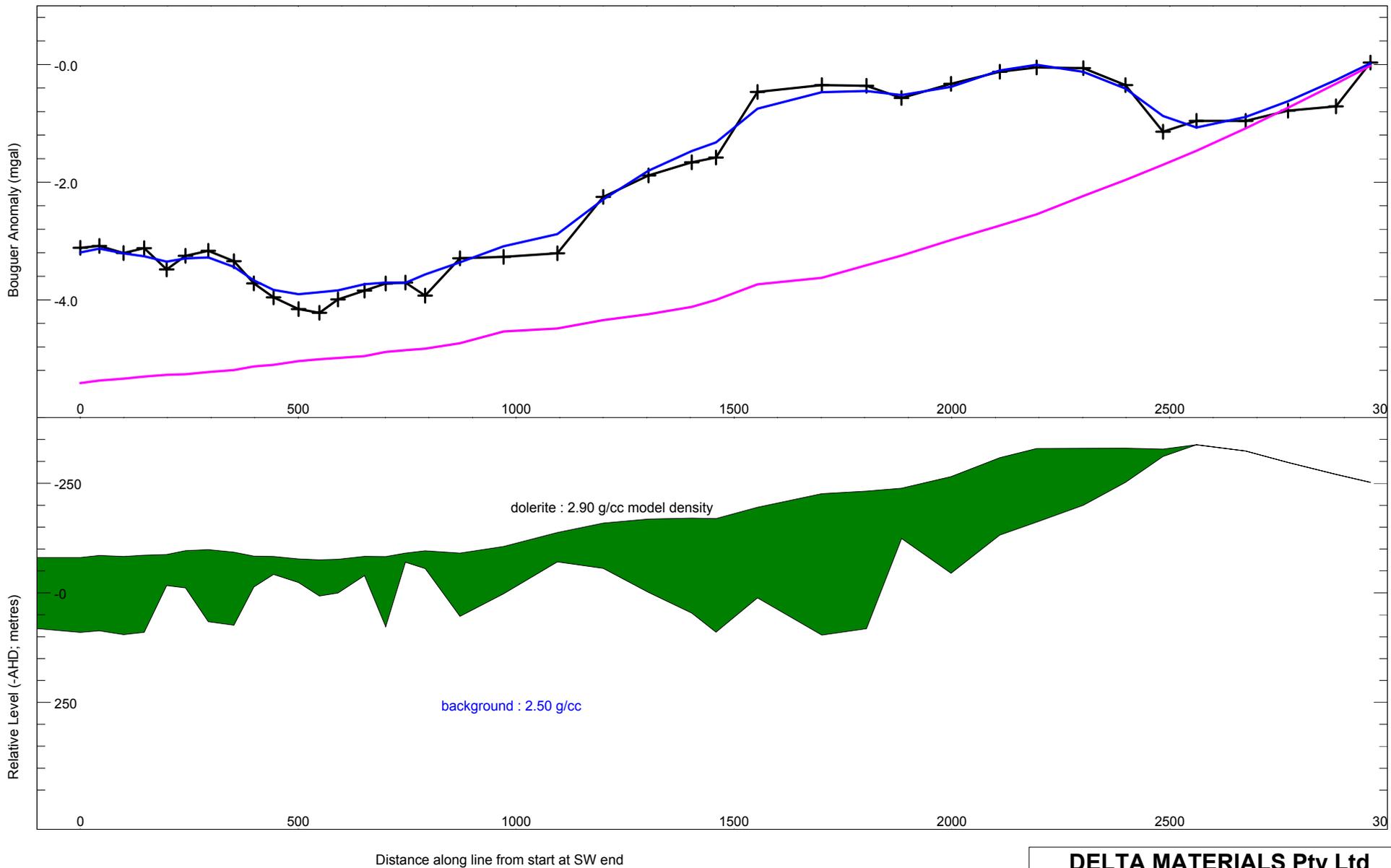Date: Feb 2010

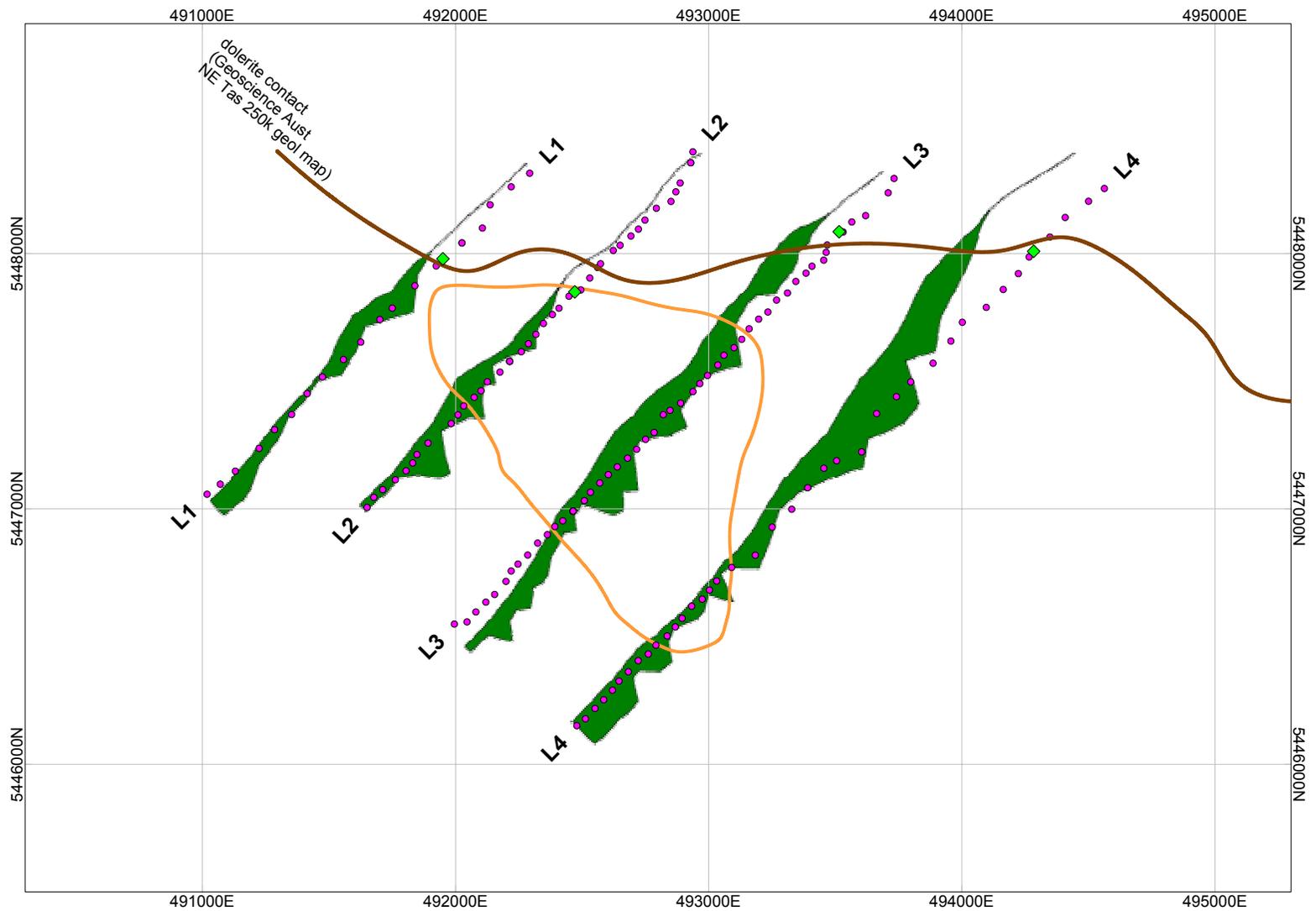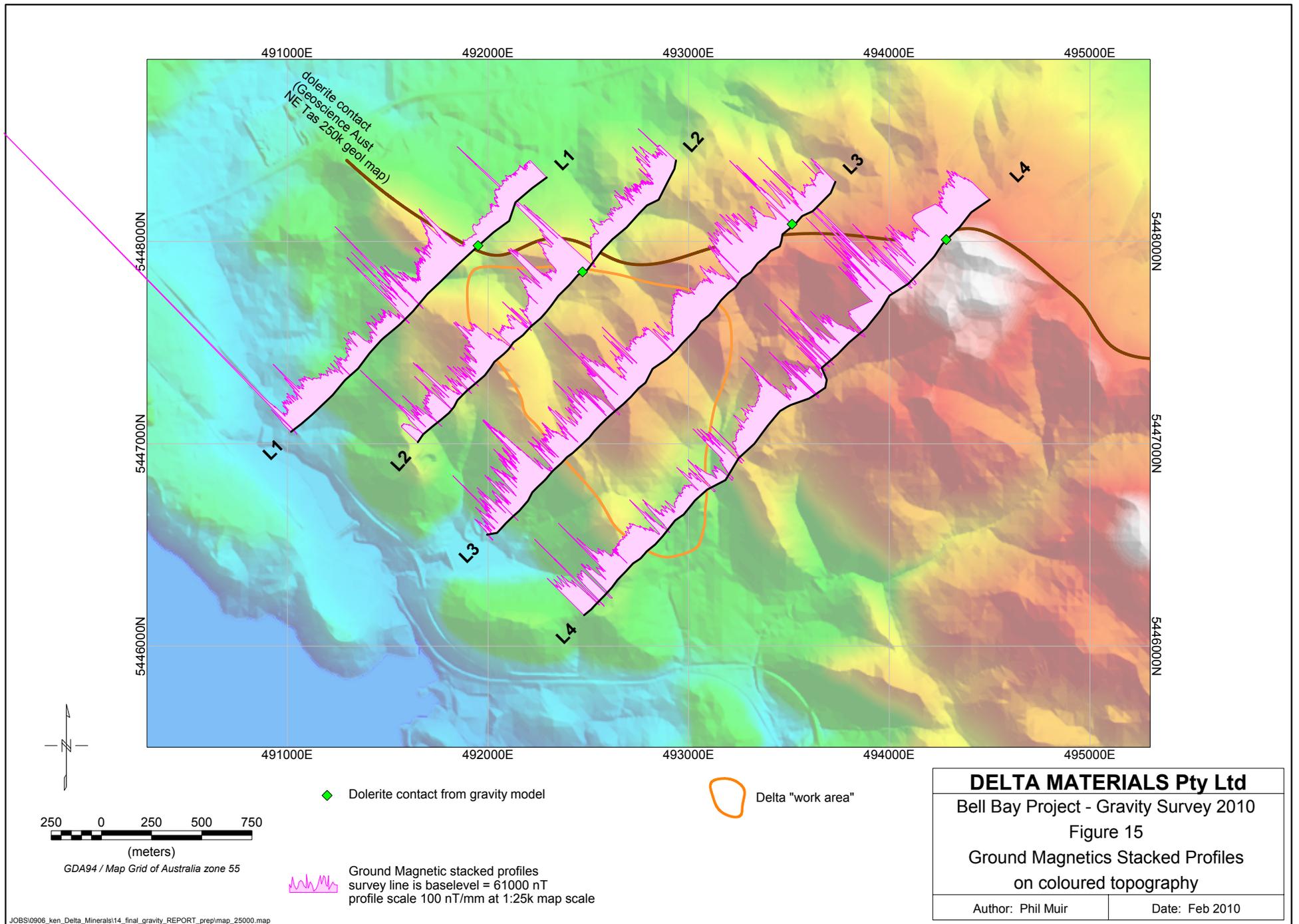Figure 13

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 13

Gravity Model Section - Line 4

(background density 2.5 g/cc)

| Author: Phil Muir | Date: Feb 2010 |

dolerite contact
(Geoscience Aust
NE Tas 250k geol map)

L1

L2

L3

L4

491000E   492000E   493000E   494000E   495000E

5448000N

5447000N

5446000N

L1

L2

L3

L4

—N—

| 250 | 0 | 250 | 500 | 750 |

(meters)

GDA94 / Map Grid of Australia zone 55

◆ Dolerite contact from gravity model

● Detailed Gravity stations

Delta "work area"

Rotated cross-sections of DOLERITE MODEL (from Figures 6 to 9) placed on this map in positions approximately along the corresponding survey line locations.

The original vertical model sections have been rotated to the horizontal plane to give a schematic illustration of the variation in modelled dolerite thickness along each survey line. Depth scale is the same as horizontal scale.

JOBS\0906_ken_Delta_Minerals\14_final_gravity_REPORT_prep\map_25000.map

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 14

Modelled Thickness of Dolerite

(schematic placement of dolerite sections)

| Author: Phil Muir | Date: Feb 2010 |

dolerite contact
(Geoscience Aust
NE Tas 250k geol map)

L1

L2

L3

L4

L1

L2

L3

L4

491000E 492000E 493000E 494000E 495000E

5448000N

5447000N

5446000N

N

250 0 250 500 750

(meters)

GDA94 / Map Grid of Australia zone 55

◆ Dolerite contact from gravity model

Delta "work area"

Ground Magnetic stacked profiles
survey line is baselevel = 61000 nT
profile scale 100 nT/mm at 1:25k map scale

DELTA MATERIALS Pty Ltd

Bell Bay Project - Gravity Survey 2010

Figure 15

Ground Magnetics Stacked Profiles

on coloured topography

Author: Phil Muir | Date: Feb 2010

JOBS\0906_ken_Delta_Minerals\14_final_gravity_REPORT_prep\map_25000.map

UR1991_22

Tasmania Department Of Resources and Energy

Division of Mines and Mineral Resources — Report 1991/22

Some physical properties of dolerite

by D. J. Sloane

Abstract

Dolerite, an igneous rock, is exposed over half of Tasmania. The good physical and chemical properties of the rock make it suitable for a wide variety of uses. Crushed rock is used as aggregate in concrete, as road sub-base and in flush seals, as facing stone in building construction, and as armour stone and rip-rap.

INTRODUCTION

Following a request for information concerning the physical properties of dolerite, a brief attempt was made to collate such information. Fresh dolerite rock is considered to be very strong and is not greatly affected by weathering. The uses for this rock are widely accepted and its physical properties are suitable for most purposes. This appears to account for the difficulty in obtaining test information, a reason confirmed by some of the information sources contacted.

Information concerning the strength properties was sought from: Rivers and Water Supply Division; University of Tasmania; Hydro-Electric Commission; major quarry companies; consultant engineers; Division of Mines and Mineral Resources; Concrete Association; and the Department of Roads and Transport.

GEOLOGY

Dolerite is an igneous rock, that is, rock initially molten and injected as a fluid into older sedimentary rocks. The magma, of quartz tholeiite composition, was emplaced as a liquid which rose upwards through the basement rocks into older sedimentary rocks of the Parmeener Supergroup. Emplacement probably occurred over an interval of 20 million years, and the average age of the rock is middle Jurassic, approximately 175 Ma (Hergt *et al.*, 1989).

Approximately half the area of Tasmania is underlain by Jurassic dolerite. The estimated volume of dolerite is of the order of 15 000 km^3 (Hergt *et al.*, 1989).

Dolerite is composed of two essential and several accessory minerals. The essential minerals are plagioclase feldspar and pyroxene, which together constitute between about 60% and 80% of the total rock composition. The accessory minerals are quartz, orthoclase, chlorite and magnetite. Quartz, orthoclase and chlorite may comprise

20% to 40% of the rock while the magnetite composition may be 2% to 3% (Leaman, 1973).

Numerous quarries occur throughout the State, with preferable sites close to contacts where jointing is platy. Decomposed, usually coarse-grained granophyric dolerite is used for surfacing unsealed roads.

PHYSICAL PROPERTIES

The physical and chemical properties of dolerite make it highly suitable for a variety of purposes. It is used mainly as crushed aggregate in concrete production, as road sub-base and in flush seals, facing stone in building construction, and as armour stone and rip-rap.

The physical properties of dolerite are given below for various localities. There is, however, no rock description for some sites. It can only be assumed that the tests were conducted on the best representative samples for each site. The physical properties of dolerite will vary depending on the grainsize, composition, degree of weathering and physical defects.
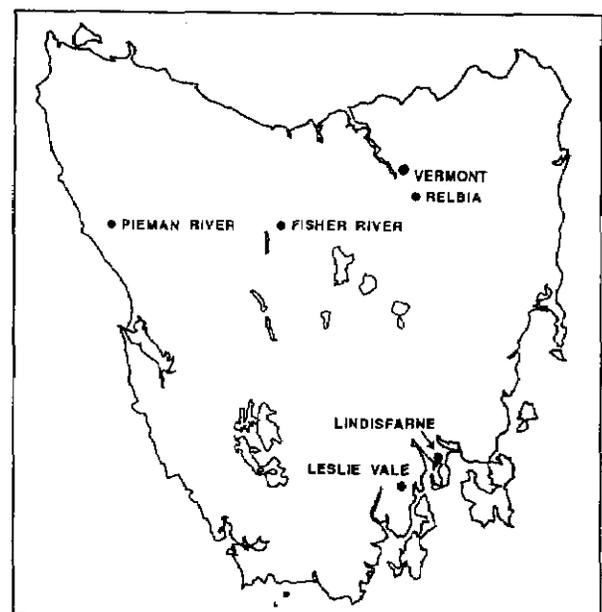

Figure 1. Location of sites of tested materials

5 cm

Leaman (1972) provided a general summary of the physical properties of dolerite for the Hobart area. The source of this information is not known but the information may be useful as a general guide.

Density:	2.80–3.10 t/m^3 (average 2.9–2.95 t/m^3)
Poissons ratio:	0.02–0.1 (weathered) 0.3–0.4 (unweathered)
Youngs modulus:	10–40 GPa (weathered) 90–110 GPa (unweathered)
Bulk modulus:	5–30 GPa (weathered) 90–100 GPa (unweathered)
Rigidity modulus:	10–50 GPa (unweathered)
Uniaxial compressive strength:	40 MPa (unweathered)
Porosity:	Approximately 1%

The physical property results from tests obtained at various specific sites (fig. 1) are presented below.

Density

Apparent Density

Lindisfarne:	2.91 t/m^3 (date ?) 2.905 t/m^3 (June 1989) 2.88 t/m^3 (20 mm screenings) 2.73 t/m^3 (37 mm crusher run)

Bulk Density — Saturated surface dry

Relbia:	2.89 t/m^3
Lindisfarne:	2.865 t/m^3 2.85 t/m^3 (20 mm screenings) 2.68 t/m^3 (37 mm crusher run)
Fisher:	3.01 t/m^3 (figure quoted as 'density', samples air dried and saturated prior to testing)

Bulk Density — Oven Dry

Relbia:	2.87 t/m^3
Lindisfarne:	2.84 t/m^3 2.83 t/m^3 (20 mm screenings) 2.65 t/m^3 (37 mm crusher run)
*Pieman (1978):	2.96 t/m^3 (mean of 18 samples) 2.95–3.004 t/m^3 (range for good quality rock)
*Pieman (1983):	2.971 t/m^3 ('Hard' rock — mean of 9 samples) 2.935 t/m^3 ('Soft' rock — mean of 10 samples)

*N.B. Results quoted as 'Dry Density'. The Pieman (1983) results subdivided samples into 'hard' and 'soft' categories, depending on the ease of percussion drilling.

Water Absorption

Relbia:	0.6%	
Lindisfarne:	0.9%	
Lindisfarne:	1.09%	(37 mm crusher run)
	0.56%	(20 mm screenings)
Pieman (1978):	0.7%	(mean of 20 samples)
	0.3–0.6%	(range of values — good quality rock)
Pieman (1983):	0.28%	('Hard' rock — mean of 9 samples)
	0.35%	('Soft' rock — mean of 10 samples)

Unconfined Compressive Strength

Relbia:	Core 1 — 90 MPa Core 2 — 125 MPa Mean — 108 MPa (50 mm diameter core approximately 200 mm in length)
Pieman (1978):	171 MPa (mean of 18 samples) 91–282 MPa (general range for good quality rock, although one sample gave 369 MPa)
Pieman (1983):	253 MPa ('Hard' rock — mean of 9 samples) 173 MPa ('Soft' rock — mean of 10 samples)
Fisher:	Mean 91 MPa (range of results was 30–155 MPa)

Schmidt Hardness

Pieman (1983):	43–44 for good quality fresh rock

Wet/Dry Strength

Lindisfarne:	Dry strength = 282 kN Wet strength = 197 kN Wet/Dry variation = 30%

Los Angeles Test Values

Lindisfarne:	Los Angeles Test 'A' grading 1985 — 16.5% (37 mm crusher run)
Lindisfarne:	March 1989 — 15.0% August 1990 — 15.0% April 1991 — 14.5%
Pieman (1978):	Los Angeles Test 'B' grading

Sample	% loss	Quality	RQD (%)	Weathering
1	13.7	Good	95	Fresh
2	9.7	Good	95–100	Fresh
3	14.5	Poor	0–75	Partly weathered
4	16.5	Poor	0–50	Partly weathered
5	6.3	Good	100	Fresh

Vermont:	Los Angeles Test 'B' grading 14% (16 mm aggregate)

Polished Aggregate Friction Values

Lindisfarne:	52 (RCA Victoria Method 374.01)
Leslie Vale:	51 (AS1141-41/42)
Vermont:	46 (AS1141-41/42) (14 mm aggregate) 45 (10 mm aggregate)

California Bearing Ratio

Vermont:	220 (37 mm crusher run)

Point Load Strength

Pieman (1978): Is (50) MPa for 20 specimens. Refers to above samples.

Sample	Median	Mean	Standard Deviation	Weathering
1	15.4	14.5	3.1	Fresh
2	13.4	11.6	5.6	Fresh
3	6.5	7.2	4.5	Partly weathered
4	4.2	4.6	3.1	Partly weathered
5	17.0	16.6	1.4	Fresh

Pieman (1983): Is (50) MPa for 20 specimens;

For 'Hard' rock	Mean — 18.1 (range 3.4 to 21.6)
For 'Soft' rock	Mean — 10.7 (range 2.6 to 20.7)

Young's Modulus

Pieman (1978)

Dynamic	93 GPa (mean of 18 samples) 87–102 GPa (range for good quality rock)
Static	96 GPa (mean of 5 samples) 101–110 GPa (range for good quality rock)

Pieman (1983)

Dynamic	102 GPa	('Hard' rock – mean of 9 samples)
	97 GPa	('Soft' rock – mean of 10 samples)

Poisson's Ratio

Pieman	0.22 (mean of 5 samples) 0.217–0.240 (range for good quality rock)

Petrographic Descriptions

Lindisfarne

Rock species –	diabase
Plagioclase –	63%
Augite –	37%

Texture –	no orientation, even-grained, dominant grain size 0.5 mm. No weathering.
Vickers hardness –	740
Drillability Index –	PNI = 32 Drilling rate index = 31 Friability index (S$_{20}$') = 31 PROTO 20 = 23, s = 1.1 Sievers J value (SJ') = 10, s = 3.8

Relbia — Sample 1

Dolerite. Fine grained, ophitic texture.

Primary minerals — plagioclase, pyroxene, hornblende and quartz. Acicular and lath-like plagioclase, equant grains of pyroxene — some alteration to chlorite along cleavage and fissures. Secondary minerals (10%) include chlorite. Quartz content 10%.

Relbia — Sample 2

Dolerite. Fine grained, ophitic texture.

Primary minerals — plagioclase, pyroxene, amphibole. Plagioclase crystals acicular, pyroxene grains subhedral with chloritised outlines. Secondary minerals (13.5%) include chlorite and quartz (8.8%).

Pavement Skid Resistance

Information source: *Relative Performance of Basalt and Dolerite Flush Seals* (DRT Report 85/93)

Summary

Test programme included a range of seal ages, traffic densities and curve radii. Skid resistance properties measured using the British Pendulum Tester. Testing generally done during winter months.

Test result trends are shown in Figure 2, where BPN skid resistance values vs. total vehicles (from AADI counts and years in service) are shown for curve radii greater than 500 m, between 500 m and 100 m, and less than or equal to 100 m. The results showed no positive indication of BPN values being a function of aggregate size (10–16 mm).

Results summary

Curve radii >100 m — Steady decline in BPN value from initial 60–65.

Curve radii <100 m — More rapid decline than above for the first 2.5×10^6 vehicles, but less than for basalt, followed by steady decline in BPN with continued traffic.

Lowest BPN value — 45 at 17.5×10^6 vehicles for curve radius less than 100 metres.

The results show that dolerites maintained higher levels of skid resistance, considered significant in the high traffic stress situations.

Figure 2

Physical properties of dolerite — BPN skid resistance versus total vehicles
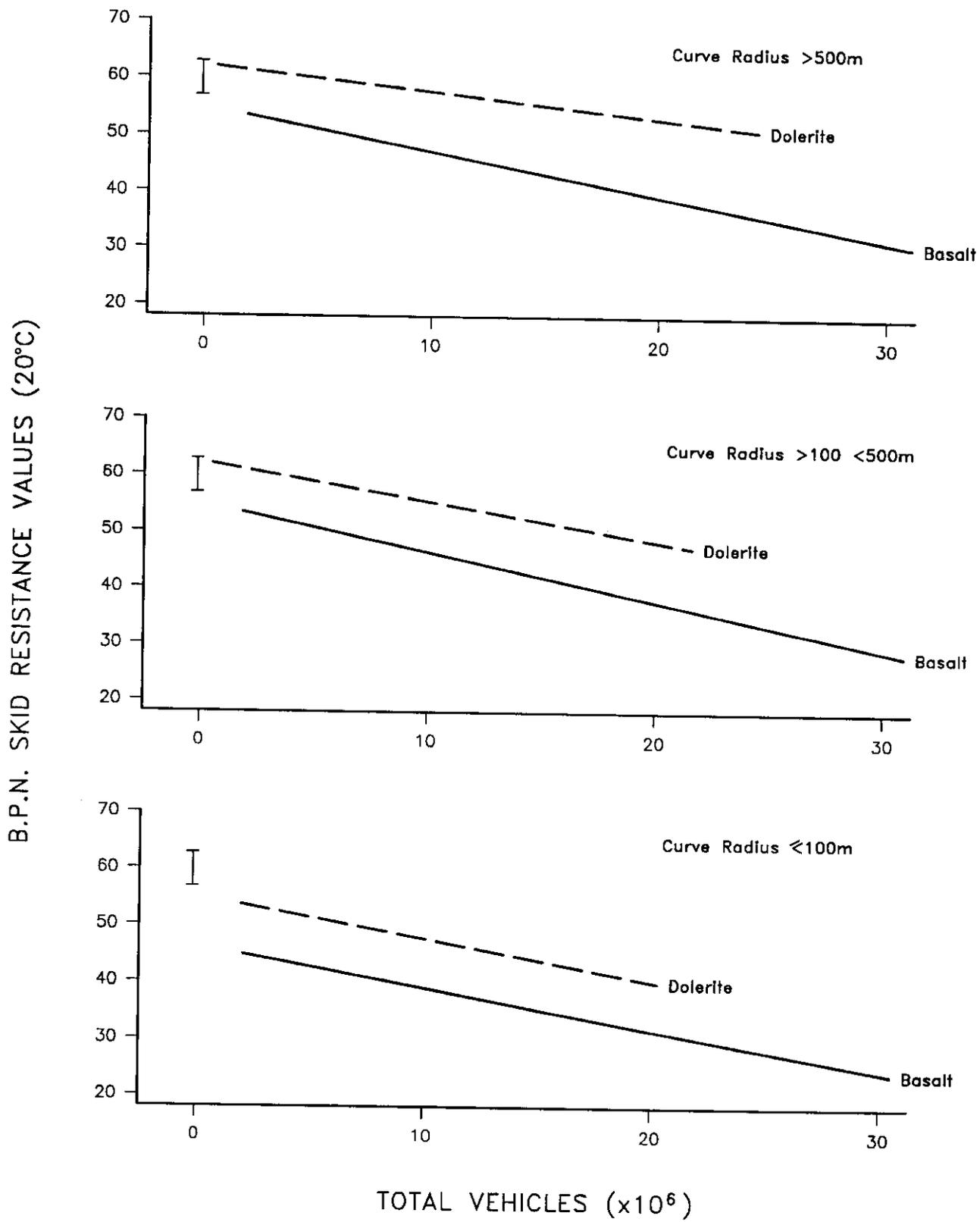
(I — Typical range of B.P.N. values on new, untrafficked surface.)
(From DRT Report 85/93)
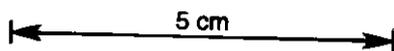
CONCLUSIONS

The results reported in the body of this report indicate a range of physical properties for dolerite rock. The results were obtained from five locations. Variations in the properties of dolerite appear to be largely related to the degree of weathering and rock defects. Other factors, such as composition and grainsize, probably play a less important role in determining rock properties.

The Pieman (1983) results indicate differences in properties of good quality 'fresh' rock within the quarry. The results are interesting but no petrographic information was reported. The only reported differences were that the 'soft' rocks had slightly discoloured joints, evident in the broken uniaxial and point load specimens. Defects, and possibly slight weathering, appear to produce the difference in properties.

Comparative testing of basalt and dolerite indicates that dolerite has better properties for road seals. Dolerite has better polished stone values and skid resistance properties.

The results are considered to be representative of the general quality of dolerite currently quarried. However, not all results provided a description of the rock tested or the method of testing. Therefore they are only considered to be indicative of each site and cannot be assumed to apply elsewhere. The results provide an overview of physical properties but do not replace specific site testing.

REFERENCES

LEAMAN, D. E. 1972. *Hobart engineering geology map series.* Department of Mines, Tasmania.

LEAMAN, D. E. 1973. The engineering properties of Tasmanian dolerite, with particular reference to the route of the Bell Bay Railway. *Tech. Rep. Dep. Mines Tasm.* 16:148–163.

HERGT, J. M.; McDOUGALL, I.; BANKS, M. R.; GREEN, D. H. 1989. Igneous Rocks. Jurassic dolerite, *in:* BURRETT, C. F.; MARTIN, E. L. (ed.). Geology and Mineral Resources of Tasmania. *Spec. Publ. geol. Soc. Aust.* 15:375–381.

DEPARTMENT OF ROADS AND TRANSPORT, 1985. Relative performance of basalt and dolerite flush seals. *Rep. Dep. Roads Transport Tasm.* 85/93.

[31 October 1991]