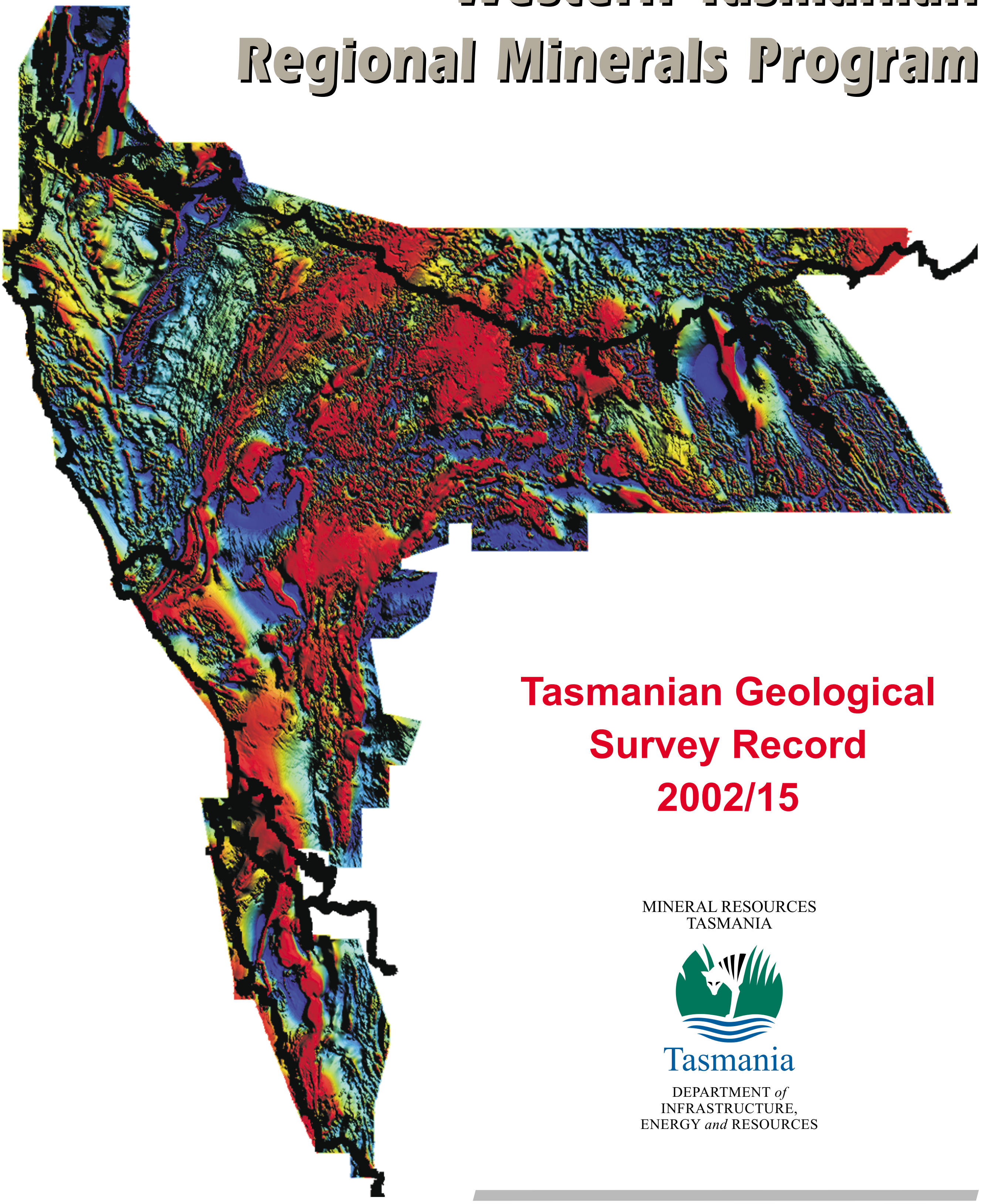
Quantitative interpretation of magnetic and gravity data for the Western Tasmanian Regional Minerals Program



Tasmanian Geological Survey Record 2002/15

MINERAL RESOURCES
TASMANIA

Tasmania
DEPARTMENT *of*
INFRASTRUCTURE,
ENERGY *and* RESOURCES

Mineral Resources Tasmania
Tasmanian Geological Survey
Record 2002/15

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SUMMARY

This report provides insights into the likely three-dimensional distribution of rocks in the upper parts of the Earth's crust in western Tasmania. The report involves quantitative interpretation by Dr David Leaman of Leaman Geophysics (L) and Steve Webster (W) of aeromagnetic (fig. 1) and radiometric data (fig. 2) acquired under the Western Tasmanian Regional Minerals Program (WTRMP) in the 2000–2001 summer, constrained where appropriate by gravity data held by Mineral Resources Tasmania (MRT).

The interpretive results confirm that the Badger Head 'Block' of Proterozoic metaquartzite and pelite is an allochthon (a structurally emplaced slice of rock, moved from its site of deposition) soled by Cambrian ultramafic rocks (L), as earlier interpreted (Leaman *et al.*, 1973) and confirmed by a recent reflection seismic survey by Geoscience Australia (Barton, 1999) and mapping by MRT (Reed and Calver, 2002). The Badger Head Block and structures as far west as Ulverstone are dominantly east dipping and involve Precambrian and Cambrian rocks. There is a major detachment at Ulverstone separating this zone from a region of predominantly west-dipping structures further west (L).

It is apparent that many major rock boundaries in central northern Tasmania may be faulted, with thin, discontinuous, magnetic slivers of magnetic ultramafic rock occurring on the fault surfaces (L). There is also evidence of rejuvenation of structures. For example, the Machinery Creek Fault near Cethana shows evidence of originating as a growth fault during Cambro–Ordovician sedimentation, with later reactivation as a thrust (L).

The Arthur Lineament at Wynyard is limited to depths of less than five kilometres and appears to dip steeply, but there may be slices of similar material at greater depth (L). Just south of the Arthur River, the Arthur Lineament is thought to be limited to depths of less than 1500 m by a major flat-dipping structure underlain by dense basement rocks (W). Further south, near the northern margin of the Meredith Granite, the rocks of the lineament are interpreted to be limited to depths of less than five kilometres by a shallowly west-dipping major thrust that bounds the western side of the Heazlewood River Ultramafic Complex and rocks of the Cleveland–Waratah association (W). As is the case further north, the eastern margin of the lineament is considered to dip steeply east. The interpreted geology, as deduced from the TASGO seismic section along the Pieman Road, is consistent with the geophysical data (W), but the section along the Cradle Mountain Link Road requires significantly more granite than interpreted from the seismic data, with the Henty Fault being a locus of intrusion (L).

The cross section on MRT's 1:25 000 scale Dempster sheet (Everard *et al.*, 1999) agrees well with the modelling of the magnetic data, although shallow sub-horizontal sheets of basaltic rocks east of the Smithton Synclinorium, not recognised in the mapping, are indicated. A major change in magnetic character across a zone extending southeast from the southern limit of the Smithton Synclinorium is indicative of a major fault zone. The magnetic data are also suggestive of a substantial shallow, or possibly exposed, body of granite east of the Norfolk Range (W).

The gravity data suggest that large volumes of granite, of probable Cambrian age, with a density of less than 2.62 t/m^3 are required under the central part of the Mount Read Volcanics from Elliott Bay to at least as far north as the Devonian ENE-trending Heemskirk Granite–Granite Tor Granite high or the Henty Fault, although it is possible the granite extends further north (L, W).

A number of possible skarns (mineralised rocks formed by the interaction of fluids exsolved from crystallising granite with adjacent country rocks) have been recognised in the modelling, including near Lorinna (L), east of Trial Harbour (W) and in the aureole of the Meredith Granite (W). Skarn immediately above granite in the Renison Bell–Colebrook Hill area has negative magnetic anomalies, indicative of reversed magnetic remanence (i.e. the direction of permanent magnetisation of the skarn differs from the present direction of the Earth's magnetic field), but more shallow skarn has positive anomalies. This characteristic pattern may prove useful in exploration.

CONTENTS

Introduction

A major product of the Western Tasmanian Regional Minerals Program (WTRMP) is the first ever consistent quality aeromagnetic and radiometric dataset over the west and northwest of Tasmania and King Island. This dataset was released in October 2001 and provides an unprecedented insight (fig. 1, 2) into the geology and structure of this highly prospective area which hosts six world-class ore deposits. To provide explorers with an introduction to the new data, Mineral Resources Tasmania (MRT) engaged three contractors to work with MRT staff to produce qualitative and quantitative interpretation documents.

Mitre Geophysics Pty Limited developed a series of Microsoft PowerPoint files presenting a regional-scale qualitative interpretation of the data, and six sheet-based interpretations at a scale of 1:100 000 (fig. 3 is an index map showing the sheet locations) including ESRI Shapefiles. This document is available as a single CD-ROM or for download from the MRT website.

For the quantitative modelling a number of profiles and areas were selected by MRT staff (fig. 4), discussed with the modelling contractors, and then reviewed before final decisions on the study areas were made. The modelling work was undertaken by Steve Webster of Steve Webster Pty Ltd and David Leaman of Leaman Geophysics, with each of the contractors contributing independent documents which form parts 1 and 2 of this record. Each profile study contains an outline of conclusions, recommendations and implications. Some of these are likely to have far-reaching ramifications for an understanding of northwest Tasmania, the West Coast Range and the prospectivity of the area.

Both the quantitative and qualitative interpretations were guided by extensive consultation and a number of workshops with geoscientists from MRT, including Ralph Bottrill, Clive Calver, John Everard, Steve Forsyth, David Green, Geoff Green, Marcus McClenaghan, Alistair Reed, Bob Richardson, David Seymour and Jafar Taheri. Other geologists including Ron Berry, David Duncan and Roger Poltock contributed through discussions.

References

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REED, A. R.; CALVER, C. R. 2002. *Geological Atlas 1:25 000 Scale Digital Series. Sheet 4644. Port Sorell (North and South)*. Mineral Resources Tasmania.

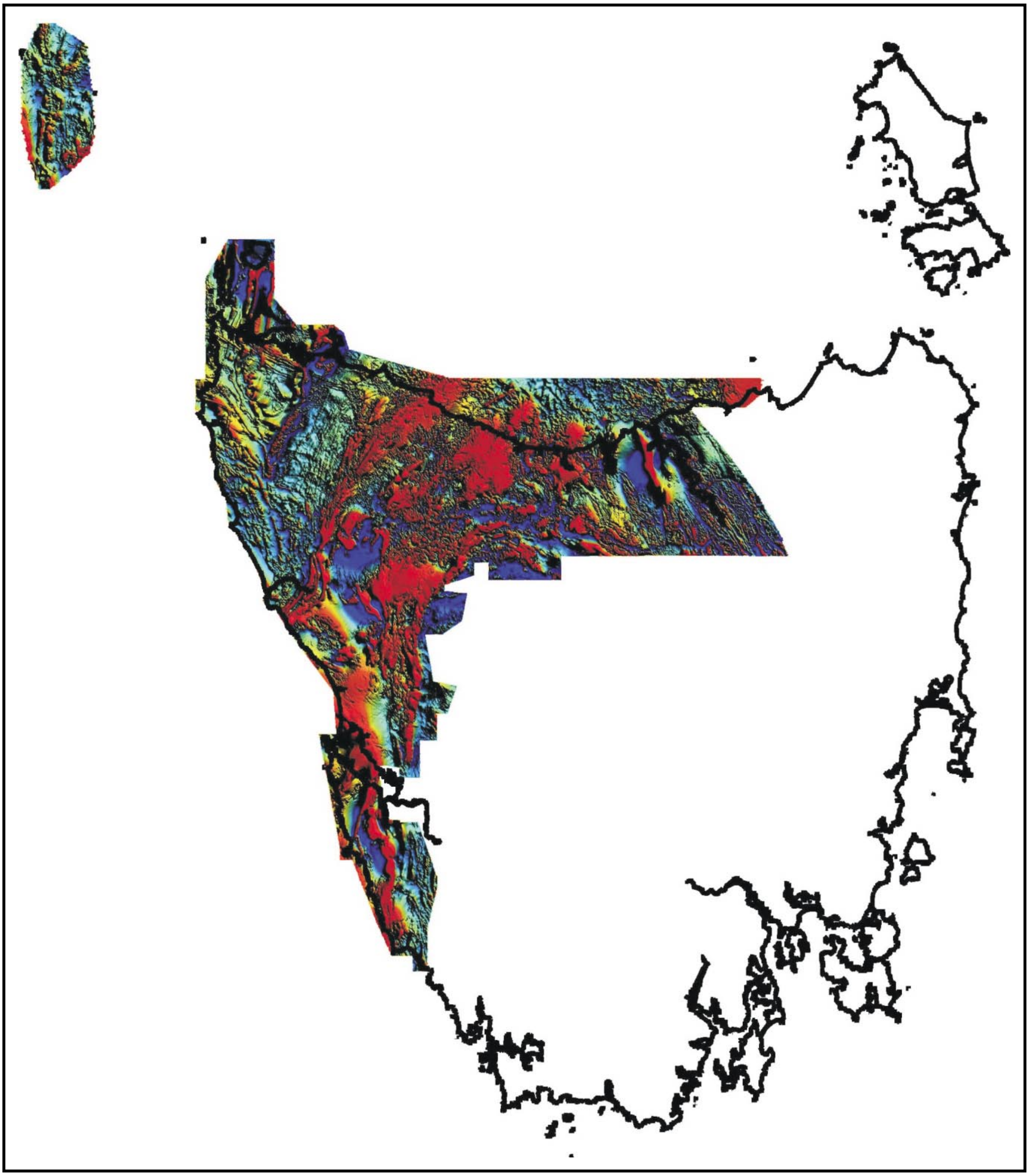


Figure 1
Aeromagnetic image of WTRMP area

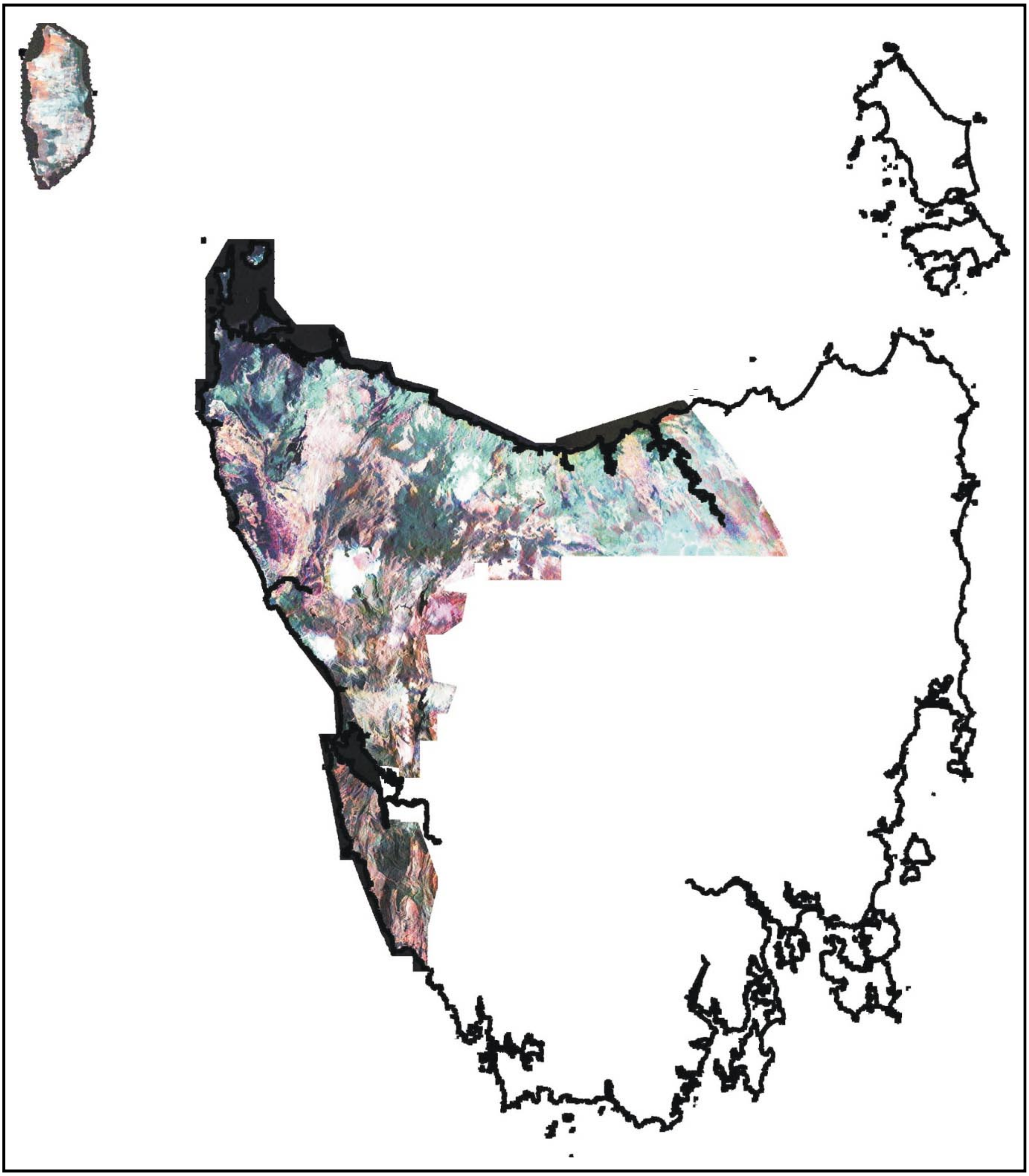


Figure 2
Radiometric image of WTRMP area

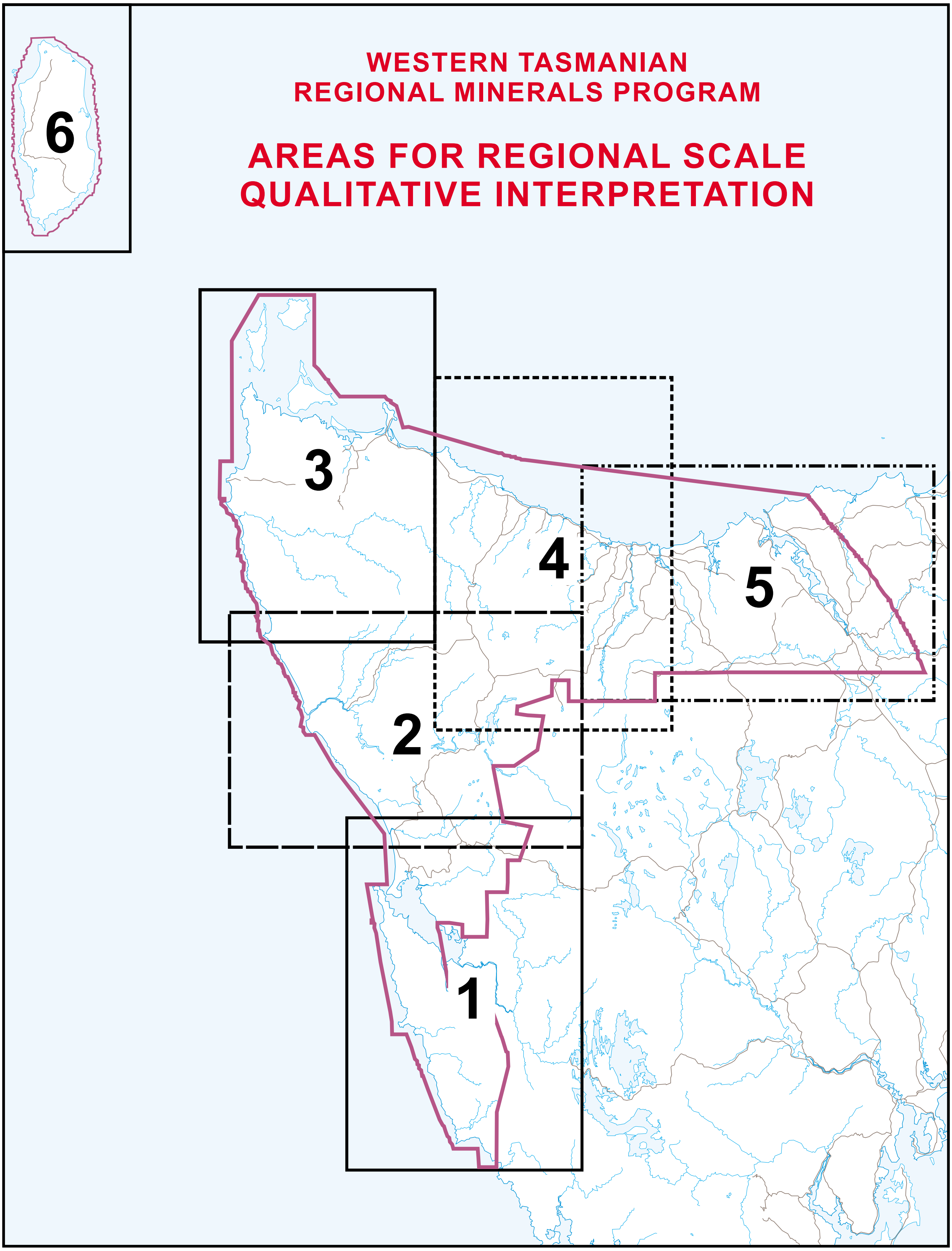

WESTERN TASMANIAN
REGIONAL MINERALS PROGRAM
AREAS FOR REGIONAL SCALE
QUALITATIVE INTERPRETATION
6
3
4
5
2
1

Figure 3

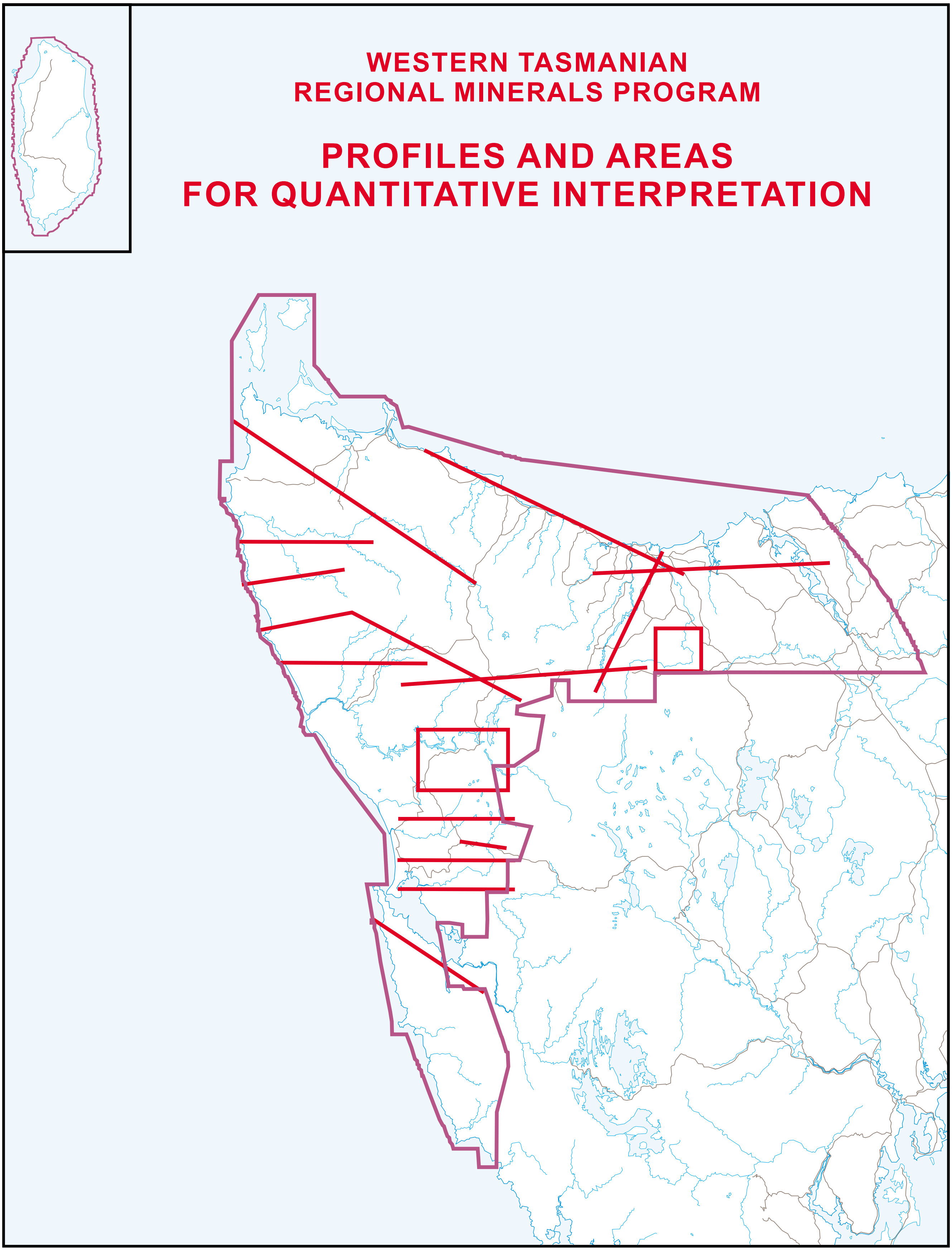

WESTERN TASMANIAN
REGIONAL MINERALS PROGRAM
PROFILES AND AREAS
FOR QUANTITATIVE INTERPRETATION

Figure 4

Mineral Resources Tasmania
Tasmanian Geological Survey
Record 2002/15

Quantitative interpretation of magnetic and gravity data for the Western Tasmanian Regional Minerals Program

Part 1:

D. E. Leaman

In this section, written by David Leaman, gravity modelling has been used to guide the scaling of rock packages and place general limits on volumes and relationships. All such models have been referred to the neutral datum established by the Mantle-91 residual separation process, which is considered to be very close to absolute datum. Similarly, magnetic modelling using the disparate data sources has been referenced to the implied true residual datum in the data sets and, as a result, there are some minor shifts compensated. This approach is faithful to both the data itself and the guidelines described in Leaman (1994*a*). No previous work has employed these rigorous controls upon interpretation and significant differences in models can be resolved.

Details of rock properties employed and general assumptions are given in Appendix 1.

Appendix 2 (available on CD only) contains details of the models, which allows proper scaling of depth estimates.

Colour coded legends for all models are provided in Appendix 1.

WEST TASMANIA STRUCTURAL SECTIONS

The most recent structural sections drawn for western Tasmania were produced by Berry (1997). These were completed using conventional balanced reconstruction techniques and a faulting model. Seven east-west cross sections were presented from south of Queenstown to Hellyer.

It was hoped that new data collected since previous comprehensive modelling by Leaman (1986*a, b*) and Payne (1991) would enable some review of structural relationships and concepts, and perhaps some consideration of alternatives.

Three lines were proposed for testing:

- 5 326 000 mN, 358 000–398 000 mE
- 5 336 000 mN
- 5 350 000 mN

Some general comments may be offered. The original sections of Berry (1997), which formed the input for the present tests, focussed on Cambrian rocks and relationships. The sections were tested by Berry and Roach (1997) but the results were unconvincing and not refined, as it was clear that many possible elements of the structure had been omitted. There was no demonstration that the reference continuations were differential to a fixed level from the observations (ground: gravity, or nominal drape: magnetics) and not simply a total continuation. The deviations in their reference profiles suggest that this was indeed the case. No simple or reliable test was effected. The material properties employed could be accepted generally (see Appendix 1) but some elements could not be explained, including a significant mass deficiency along the West Coast Range. Two other serious problems with the balanced sections relate to whether the complex of rocks known to be present can be balanced due to lack of continuity and variability in thickness, and whether all units which contribute to the structure were included.

Comparison with Leaman (1986a, b) shows that Eocambrian and Late Precambrian rocks do contribute substantially to the potential fields.

LINE 5 326 000 mN

The Berry section was faithfully modelled and found to be unsupportable (fig. 5). The only approximate fit (and only when the Macquarie Harbour Tertiary Basin was added to the Berry concept) extended from 358 000 mE to 370 000 mE. An enormous mass deficiency, in excess of 10 mgal, was related to the range and beyond onto siliceous Tyennan basement. This finding means that the source of deficiency is not in basement, or due to basement rocks, as these already provide the background contrast. The basement deficiency could be explained by thick, concealed thrust slices of Siluro-Devonian rocks but this is a forced solution and not generally satisfactory (see below and the Cape Sorell, Mt Osmund and Linda sections). This solution was fully tested and can work systematically in the region east of the King River axis. The crucial mismatch between 375 000 mE and 390 000 mE corresponds to outcropping volcanic sequences. These have considerable volume but even their total removal from the model does not resolve the problem; indeed it makes little difference.

The only workable explanation lies in the insertion of a large granite mass which is essentially non magnetic and has a bulk density of 2.62 t/m^3 or less. This solution (fig. 6), or a refinement in which a part of the central volcanic pile is slightly altered (reduced density — silicification?) (fig. 7), can explain the general response pattern. The implication of these models is that portions of the original Berry model, and the general bulk thicknesses, are reasonable overall and that no significant older sequence (such as Crimson Creek equivalents) is included in this section other than near Strahan. The data fit is easier with a granite density of 2.60, especially near its roof, and the roof depth could be increased slightly, from the present minimum of about 1000 m below surface.

Magnetic data set against the same regional reference are dominated by sources near the Cambrian granites of the range and other intensely magnetised material near Macquarie Harbour. The Crimson Creek Formation equivalents south of Strahan contribute a minor anomaly near 368 000 mE–370 000 mE. The range anomaly can be ascribed to granites or alteration about or in them. The western anomalies can only be produced by materials with the properties of ultramafic rocks present in thin slices. The anomaly at 362 000 mE, although appearing to possess a simple form, is compound and derived from the interference of several sources. The most important of these are a shallow west-dipping slice and a more steeply east-dipping slice which must sole to considerable depth as suggested by the long gradient to about mid section (fig. 8).

LINE 5 336 000 mN

Similar comments apply for this profile.

The initial curve fit (fig. 9) for the Berry model is actually worse than for line 5 326 000 mN and the enormous thickness of Siluro-Devonian rocks proposed cannot be sustained. This thickness must be much reduced and the underlying Cambrian and Eocambrian rocks thickened. Nor can any large slice of Denison Group be underthrust. Any viable solution depends upon a large granite extending in depth from about 1000 m below surface (at the contrast employed). The fit remains poor (fig. 10) unless the roof of this body is irregularly domed or capped with low density phases (2.58–2.59 t/m^3). The presented model uses a contrast reduction by alteration (fig. 11) at the base of the volcanic pile but a general reduction in density for the entire mass would assist.

Magnetic data require ultramafic soling of the western fold zone and it is likely that segments of this zone (358 000 mE–370 000 mE) are overthrust (fig. 12). Other significant anomalies are associated with Cambrian granites (and altered associated materials), parts of the volcanic pile near 379 000 mE–380 000 mE, and in a dense variant (amphibolites?) within the basement complex (395 000 mE). Any ultramafic rocks present must be deep in order to yield the smooth responses observed. An indication of how all magnetic sources interfere to generate the observed field is provided in Figure 13.

LINE 5 350 000 mN

Similar comments apply for this section except the entire volcanic and sedimentary package is much thinner along section. Any deep granite is about 2000 m below surface (fig. 14, 15). Magnetic sources are restricted to the package of Cambrian rocks within the range, the west side of the volcanic complex, a belt of volcanic rocks near 374 000 mE and a fragment of deep volcanic rocks (fig. 16).

All sections, taken as a group, show that the Cambrian granitoids of the West Coast Range are volume limited but magnetic — or they are marginally altered. No other part of the post-Cambrian sequence is significantly magnetised. A large granite mass extends the length of the range (see notes below and discussion for Mt Osmund and Cape Sorell) and is not much broader than the range complex. The properties of this granite are comparable with most Devonian granites.

Whatever its age, this granite was clearly intruded along a major structural boundary at the western side of the Tyennan core and eastern side of the early Palaeozoic basin complexes. The absence of Devonian-style mineralisation above such a shallow roof suggests that the mass is Cambrian and probably related to the development of the volcanic pile.

The presence and involvement of ultramafic rocks west of the range indicates some dislocation of structures and sequence (see also Cape Sorell). The slices of ultramafic rocks appear to be restricted to regions in which rocks equivalent to Crimson Creek Formation are present. Only those portions of the sequence may have been involved in that disruption.

ABOUT GRANITES

Some large Devonian granitoids dominate western Tasmania. These have been described regionally by Leaman and Richardson (1989), with some more recent 3D analysis by Leaman Geophysics being released for the first time with this report (fig. 17). Similar work is continuing for other plutons. The most recent refined modelling of the Meredith and Dolcoath granites is available in Leaman (1988, 1991*a*).

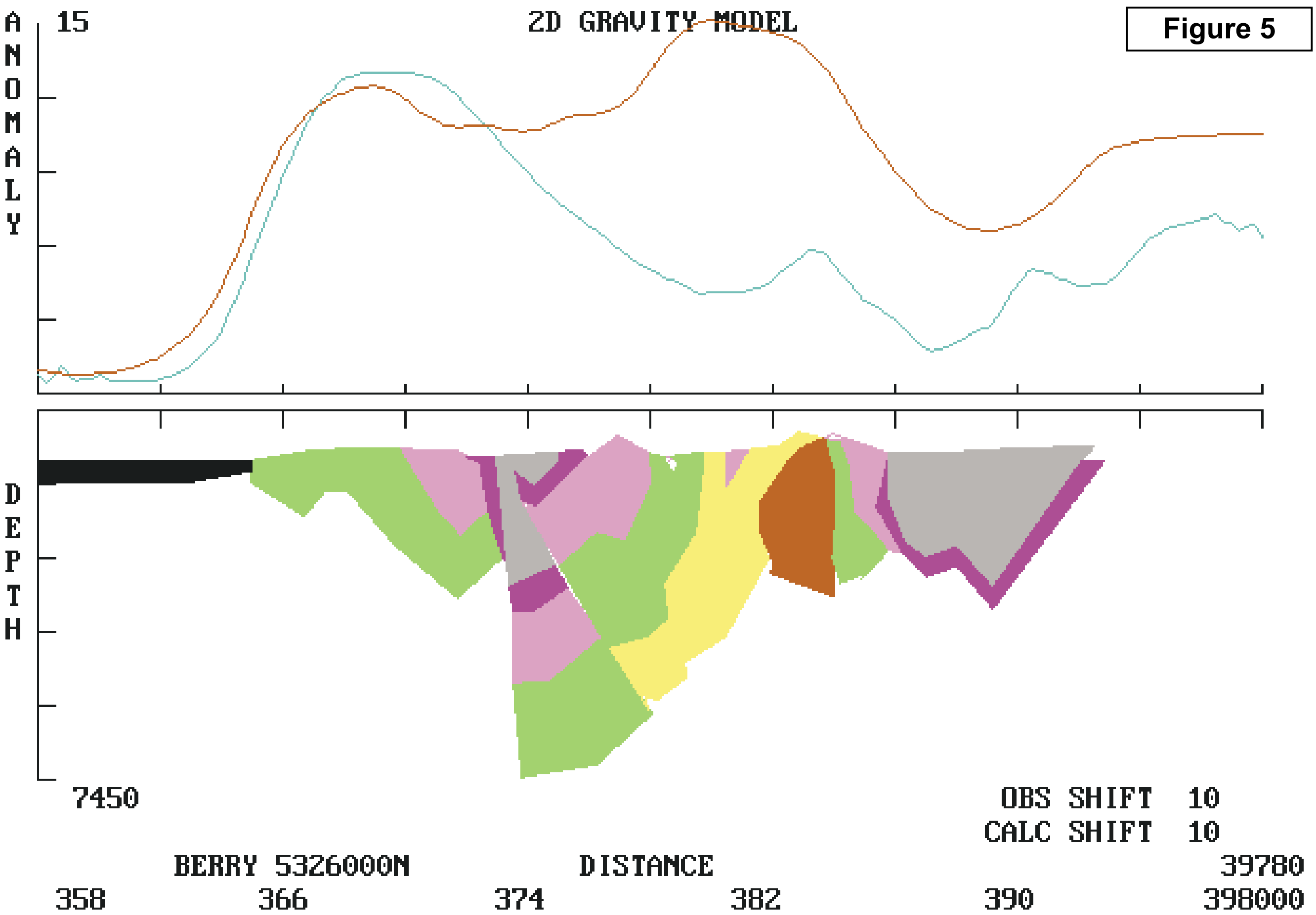
The coherent 3D model of the Granite Tor–Pine Hill–Heemskirk, and Pieman–Heemskirk–Grandfathers, complex reveals some interesting characteristics. One group of plutons is generally orientated ENE, and the other approximately N–S. Where data permit it has been possible to define relatively subtle character and show that the pluton roof is irregular, spined and locally domed. Domes reach into the area beneath Renison, south Rosebery and east Hercules, with spines extending beneath Colebrook Hill and Sterling Valley. Many spines are orientated N–S or NNW–SSE upon a gross ENE axis. This intrusive complex extends east of the Forth River.

The Granite Tor–Pine Hill complex appears to be structurally controlled and to have intruded along a fundamental crustal element. The ENE trend is dominant in the Tasmanian crust and is visible in the digital terrain model at long wavelengths.

The work reported above on the Berry regional lines, and at Cape Sorell and Mt Osmund, shows that the anomalous basement first identified by Leaman (1986*b*), and Berry and Roach (1997), is due to an additional granite complex with similar physical properties but a structural and stratigraphic, and possibly volcanic, association which implies a Cambrian age. This complex extends N–S from Elliott Bay but appears to have been terminated near the Henty Fault and the Granite Tor–Pine Hill axis. A close review of the residual Bouguer anomaly map of Tasmania suggests that this complex might extend north of the Granite Tor axis towards the Housetop Granite. There is scope for much further review of the nature, extent, origin and age of this additional granite.

Limited data are available from Cambrian granites which possess comparable properties. Archer (1989) and Payne (1991) presented some data which suggested that portions of the Murchison Granite might have a bulk density less than 2.60 t/m^3. Similar suggestions apply to the granite at Elliott Bay. Leaman and Richardson (1989) summarised earlier data and concluded that the Cambrian granites were variable; some less dense than 2.64 t/m^3 but others of the order of 2.68 and 2.71. It was unclear what the proportions really are for these intrusive rocks. This interpretation suggests that a density less than 2.62 t/m^3 is required in bulk. Magnetic properties are a complicating factor, as many exposed parts of the Cambrian granites appear to be quite strongly magnetised. It is not clear whether the effect is due to skin and alteration effects or an intrinsic property of the granites themselves but the effect is not universal as demonstrated by the Dove River Complex.

The inference of an additional plutonic complex in western Tasmania, which might well be Cambrian in age, requires some careful review and testing. Comprehensive sampling studies, which are not biassed towards any colour or alteration or composition factors, are needed. The present work predicts that the dominant lithology might well have a fresh density of about 2.60 t/m^3 and be non magnetic.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15
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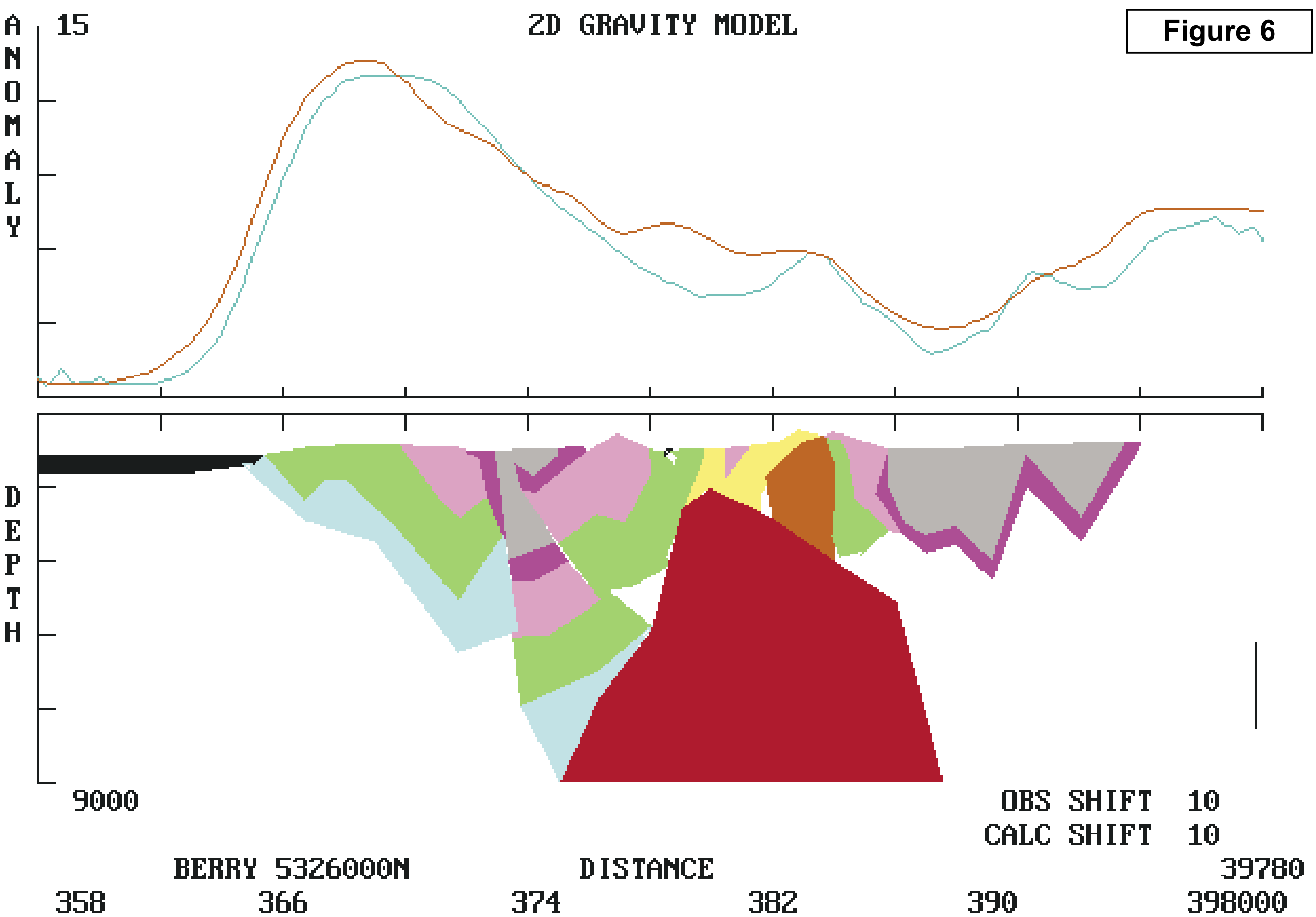
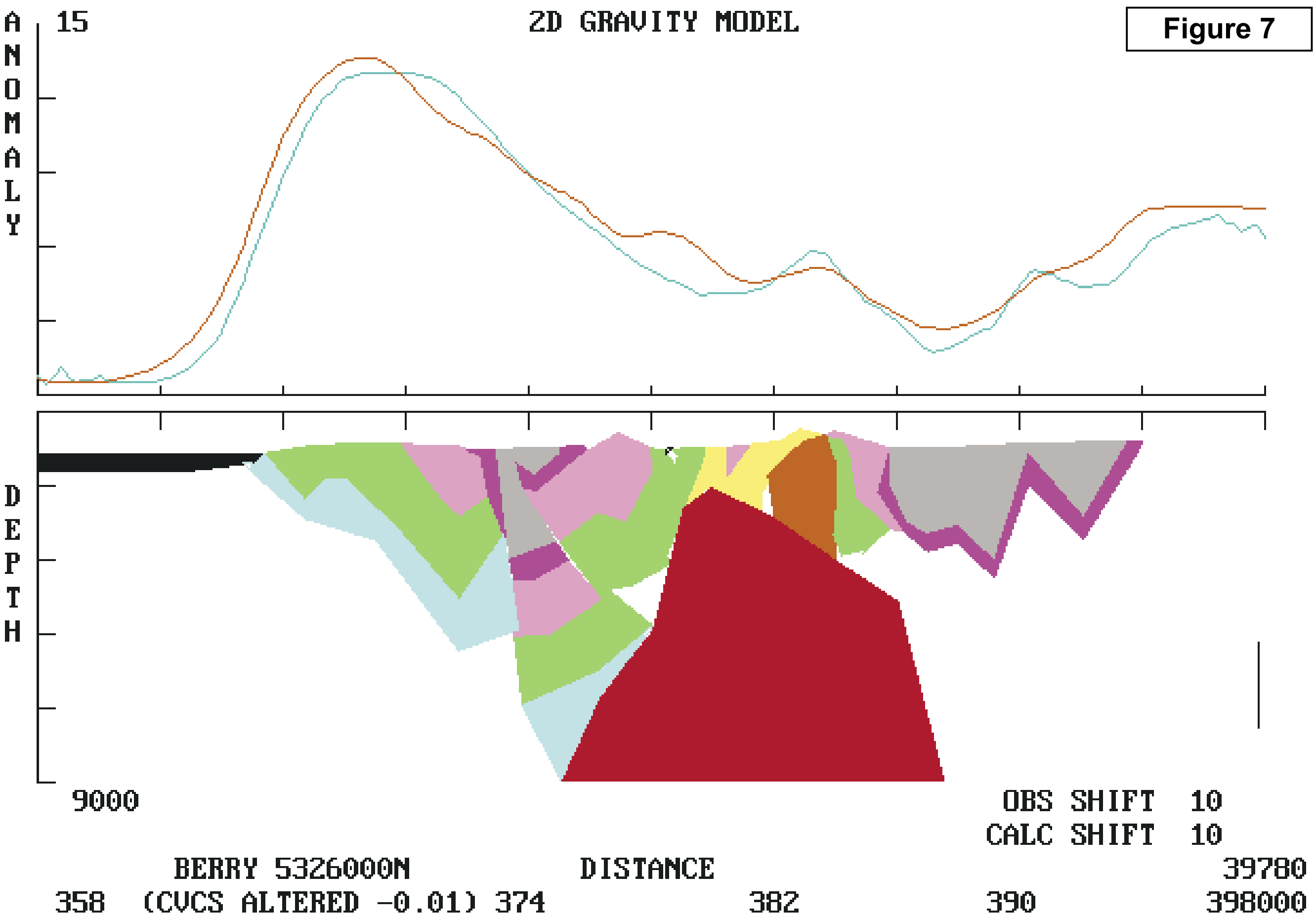
39780
358
366
374
382
390
398000


2D GRAVITY MODEL
Figure 6
ANOMALY
15
DEPTH
9000
OBS SHIFT 10
CALC SHIFT 10
BERRY 5326000N
DISTANCE
39780
358
366
374
382
390
398000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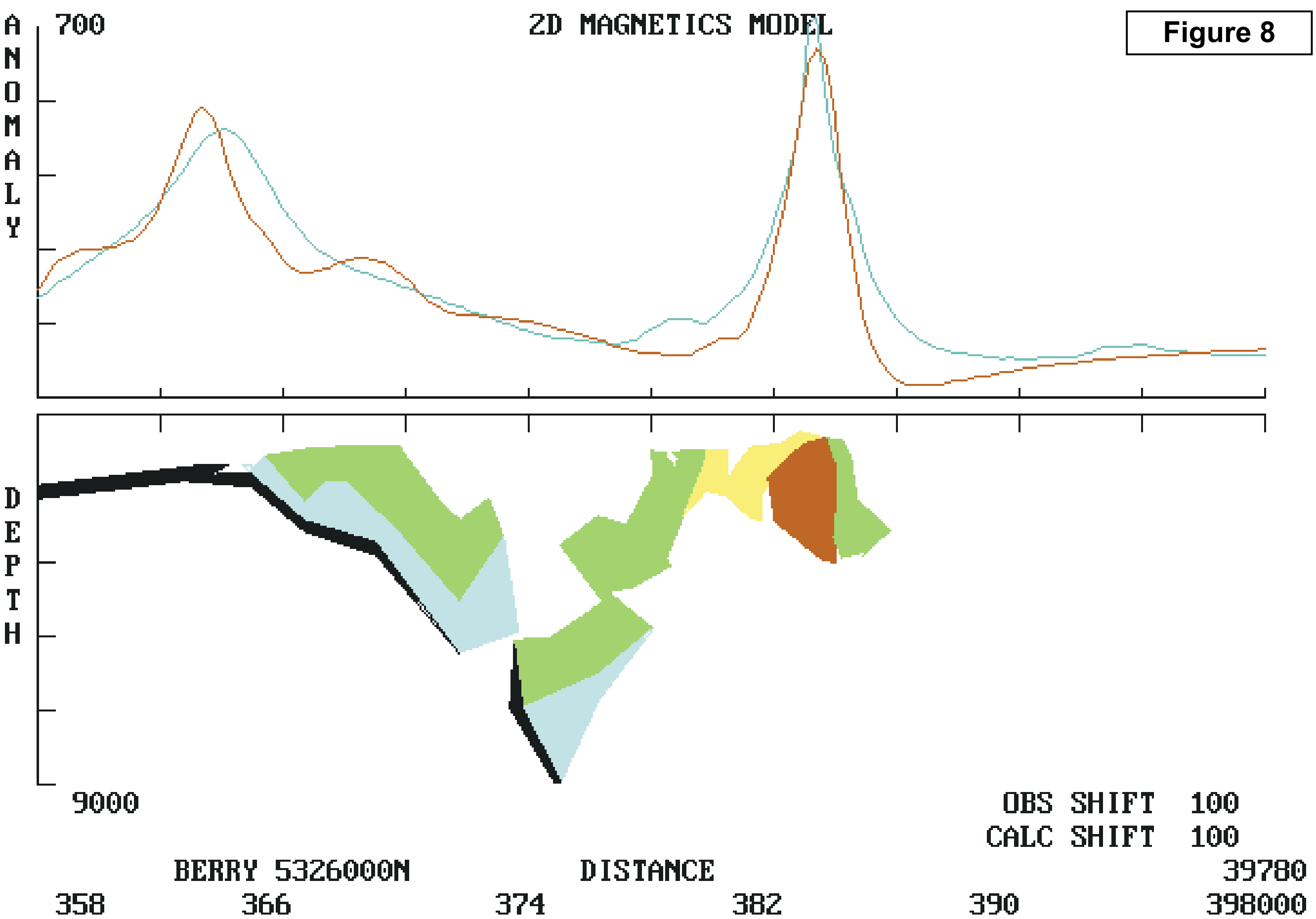
ANOMALY
15
DEPTH
9000
OBS SHIFT 10
CALC SHIFT 10
BERRY 5326000N
DISTANCE
39780
358
(CVCS ALTERED -0.01) 374
382
390
398000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DISTANCE
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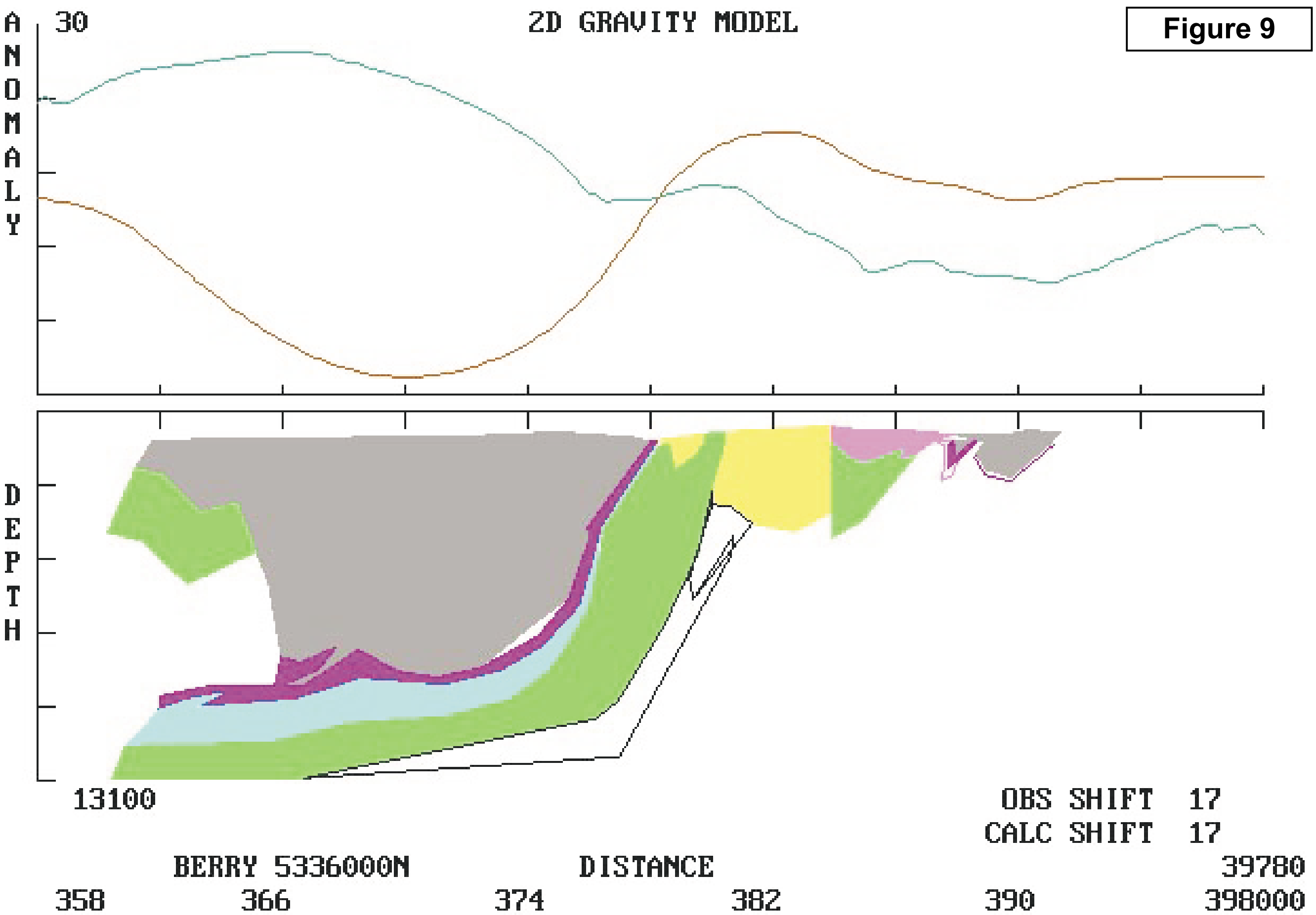
366
374
382
390
398000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ANOMALY
30
2D GRAVITY MODEL
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OBS SHIFT 17
CALC SHIFT 17
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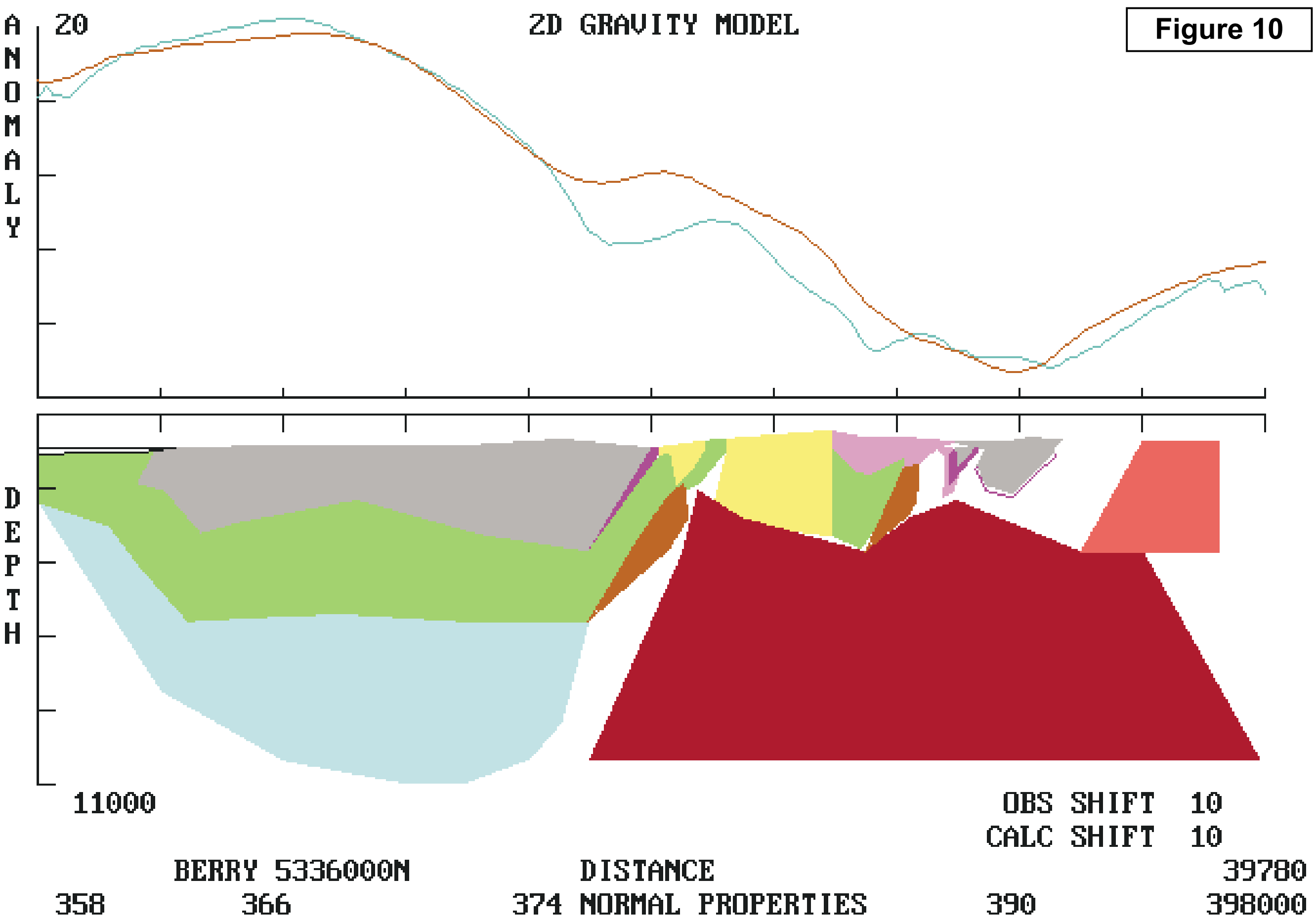
DISTANCE
39780
358
366
374
382
390
398000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ANOMALY
20
2D GRAVITY MODEL
DEPTH
11000
OBS SHIFT 10
CALC SHIFT 10
BERRY 5336000N
DISTANCE
39780
358
366
374 NORMAL PROPERTIES
390
398000

Figure 11

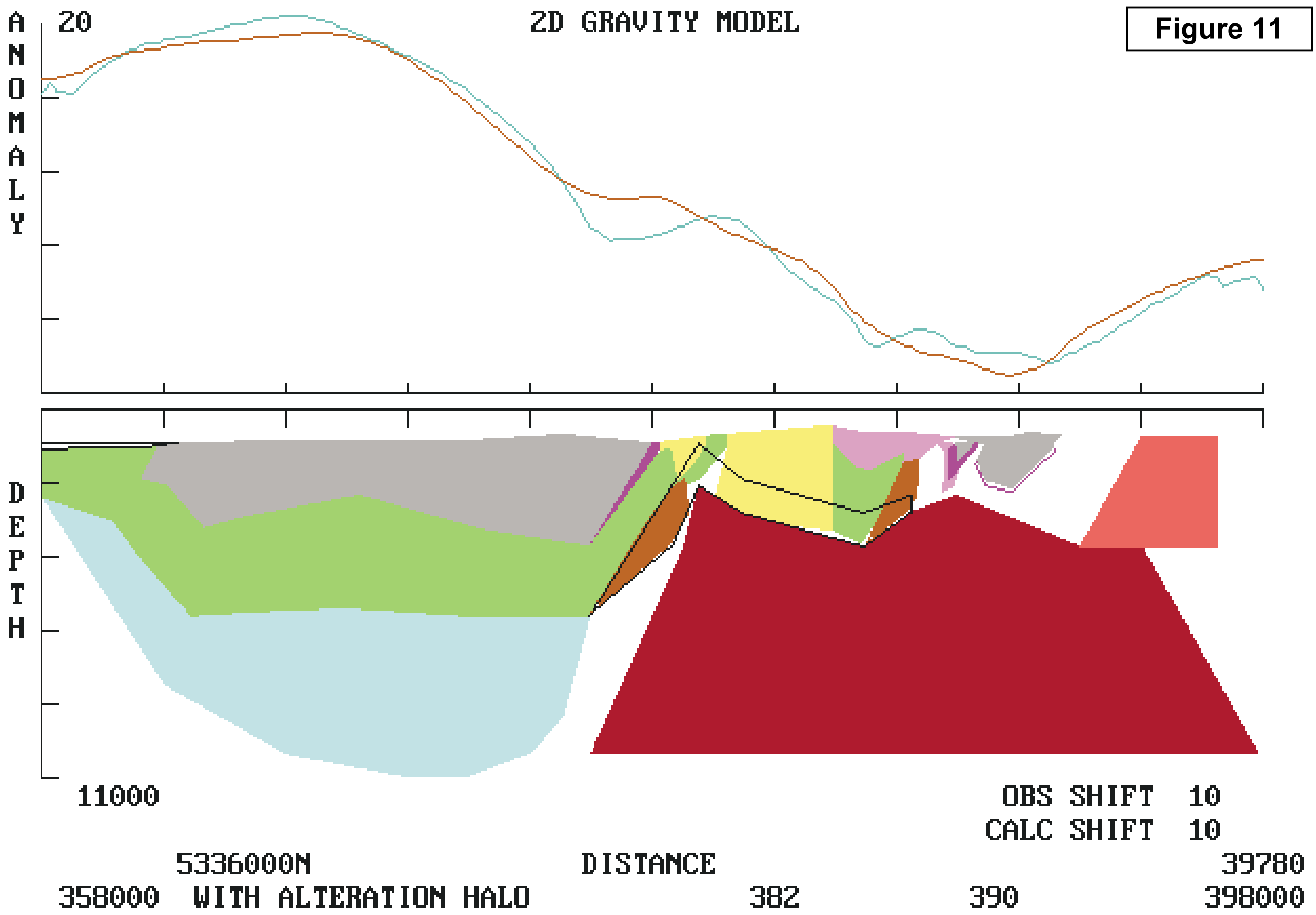
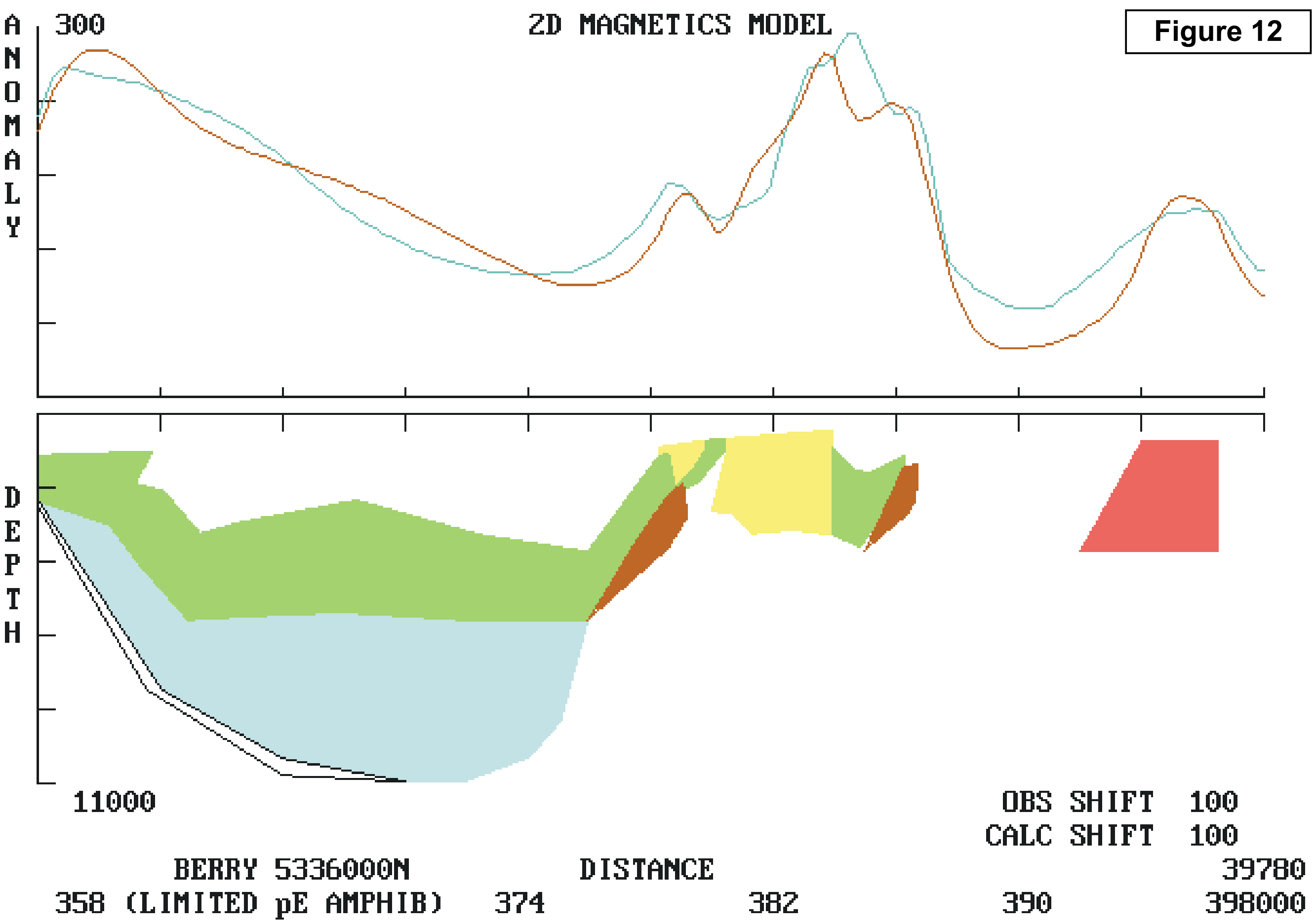


Figure 12



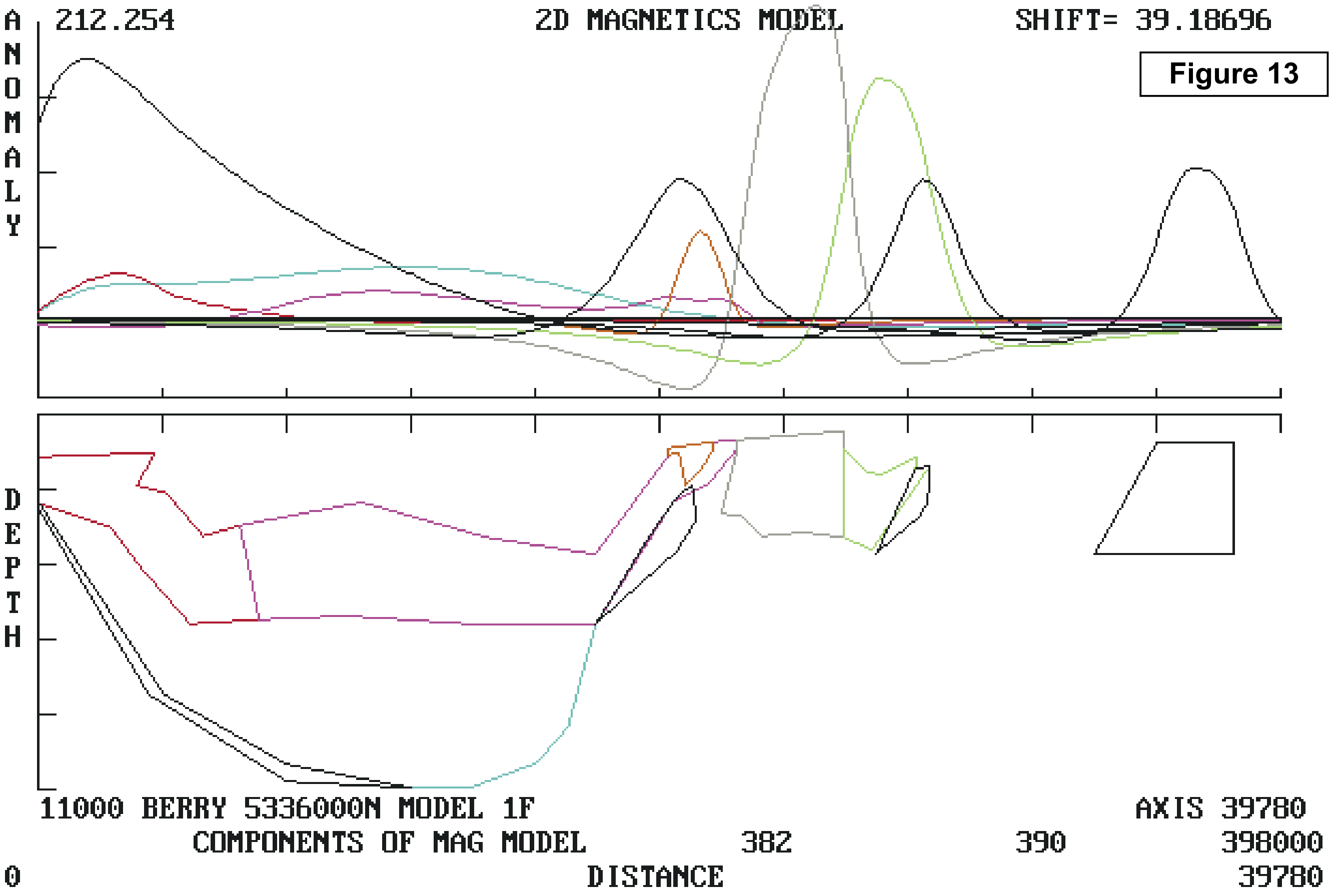

A N O M A L Y
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Figure 13
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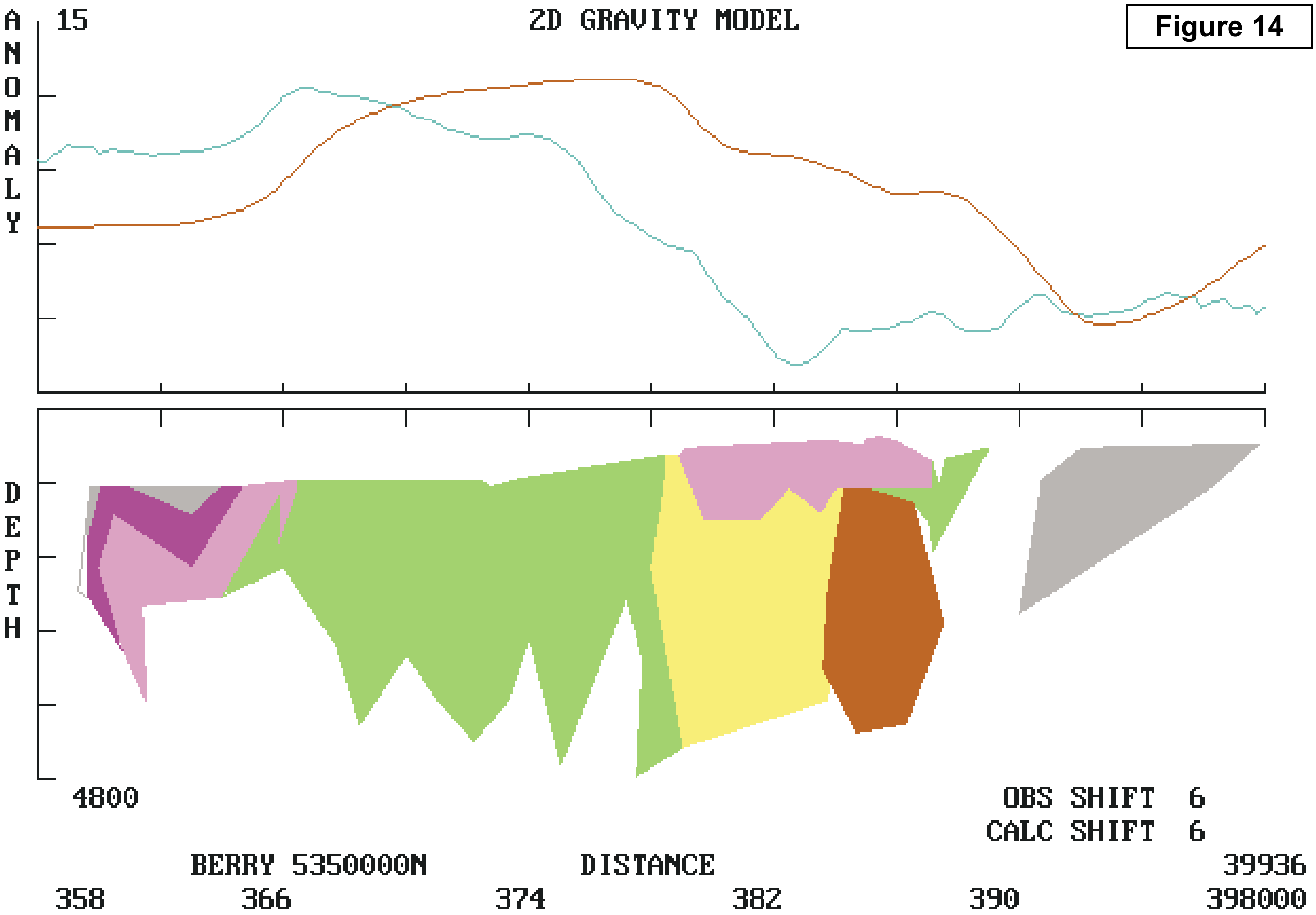
398000
0
DISTANCE
39780


A N O M A L Y
15
2D GRAVITY MODEL
Figure 14
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CALC SHIFT 6
BERRY 5350000N
DISTANCE
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374
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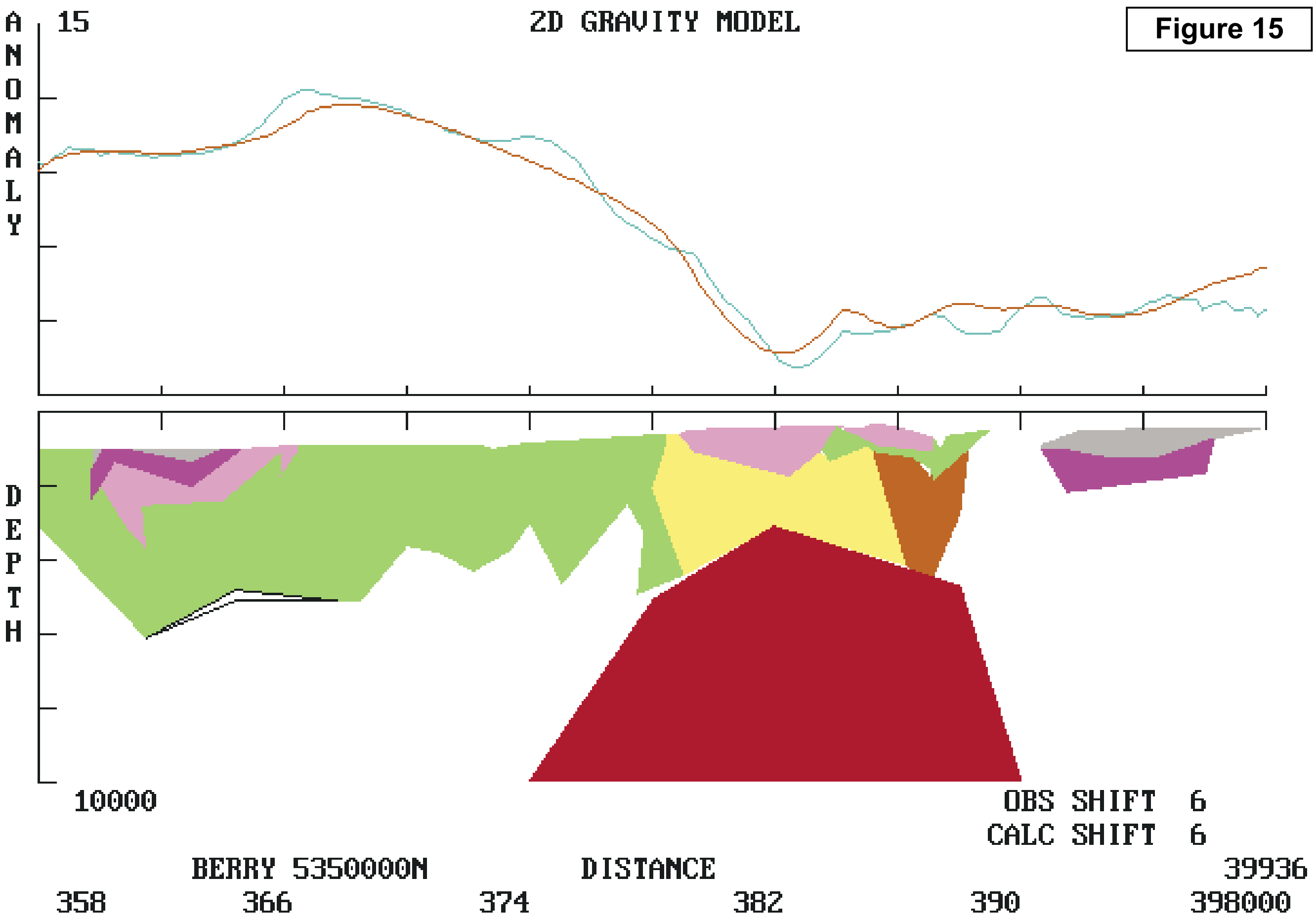

Figure 15
2D GRAVITY MODEL
ANOMALY
15
DEPTH
10000
OBS SHIFT 6
CALC SHIFT 6
BERRY 5350000N
DISTANCE
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358
366
374
382
390
398000

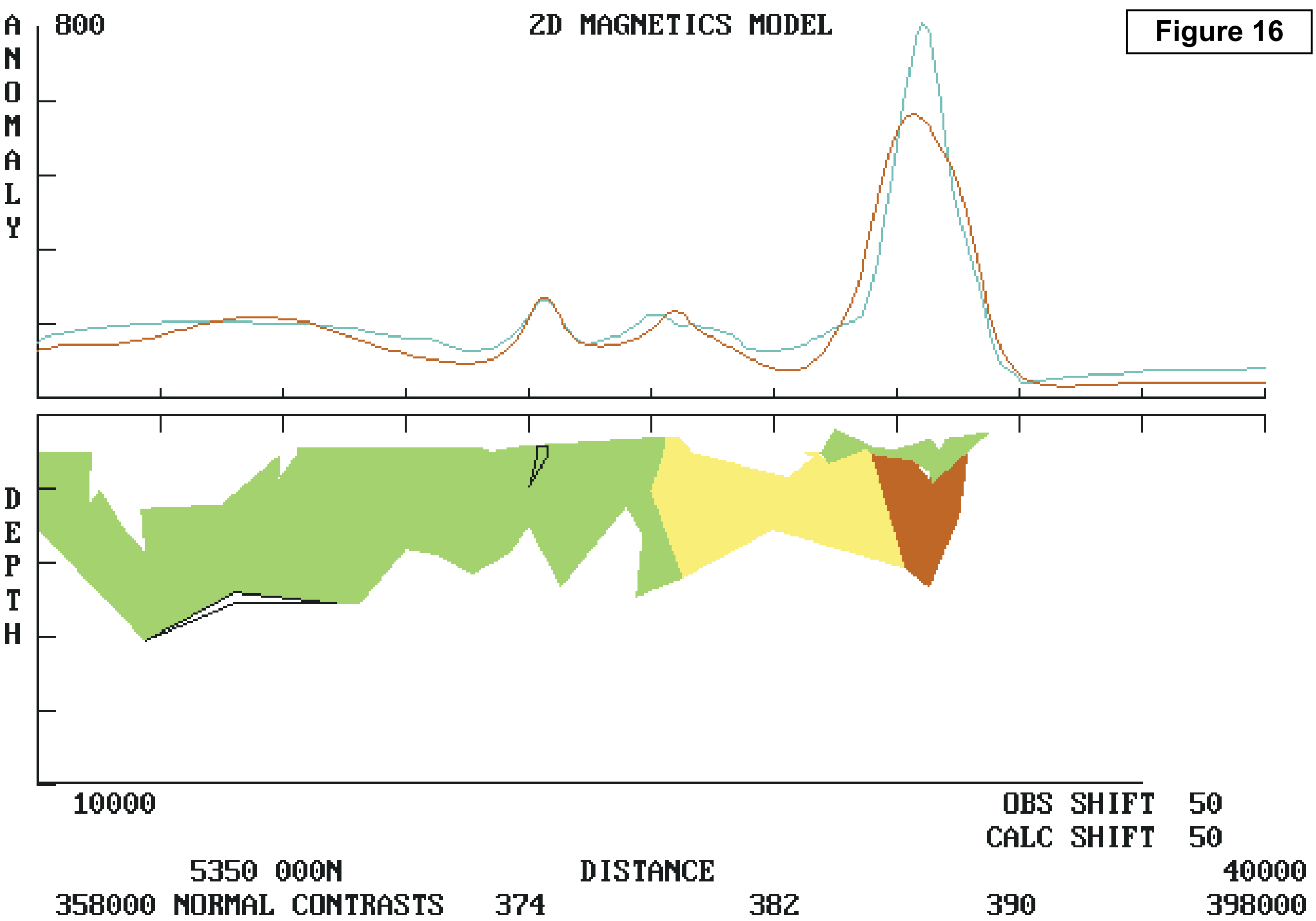

Figure 16
2D MAGNETICS MODEL
ANOMALY
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DEPTH
10000
OBS SHIFT 50
CALC SHIFT 50
5350 000N
DISTANCE
40000
358000 NORMAL CONTRASTS
374
382
390
398000

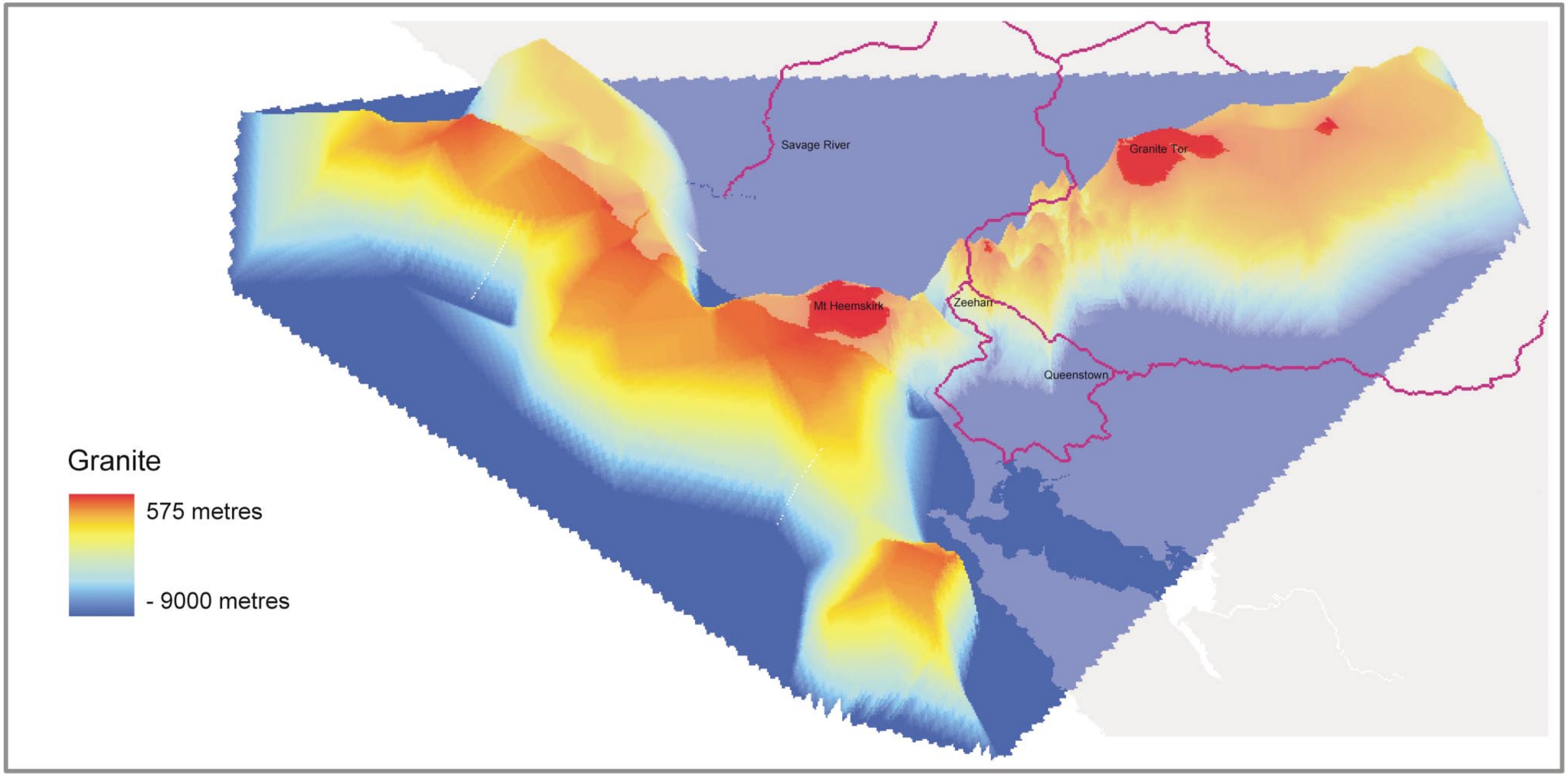


Figure 17. *Three-dimensional model of western Tasmanian granites*

LINDA

379 000 mE/5 342 000 mN – 395 000 mE/5 340 000 mN

This section is one of the most interesting and intriguing in Tasmanian geology and potentially the most important. Key problems include how much conglomerate is present beneath Mt Lyell, the content of the volcanic rocks east of the Lyell Fault and Iron Blow, and just what underlies these units.

Gravity data (fig. 18) show that the solution is not sensitive to the volume of volcanic rocks included but that there is a total depth limitation on the volume of volcanic and Ordovician rocks which may be present. No reasonable thicknesses, or indeed minimum thicknesses, can account for the field which is anomalously low (see also ***West Tasmania*** section). A large, low density volume must be present at shallow depth beneath the range and must have a density less than 2.62 t/m^3. At this density it could be exposed near the level of the King River. A more likely solution is a slightly lower density and moderate roof depth. The gravity model shown incorporates an altered volume to reduce the calculated field and may be translated as silicified volcanic rocks or perhaps a more siliceous phase in the roof of the underlying granitoid.

Magnetic data fully support these inferences (fig. 19).

The Great Lyell Fault may extend to depths of at least -900 m with the known dip before curling eastward. A very thick, local wedge of conglomerate appears to be present next to the fault.

The present data were modelled against a reference level of 1000 m in order to incorporate aspects of the topography. A more complete evaluation of the issues raised by this section requires 3D methods and, while the magnetic data are suitable, additional gravity data are required.

A further problem, previously identified by Leaman (1986*a*), is associated with the eastern face of the range, which has proven very difficult to model. 3D techniques might resolve the structures along this axis.

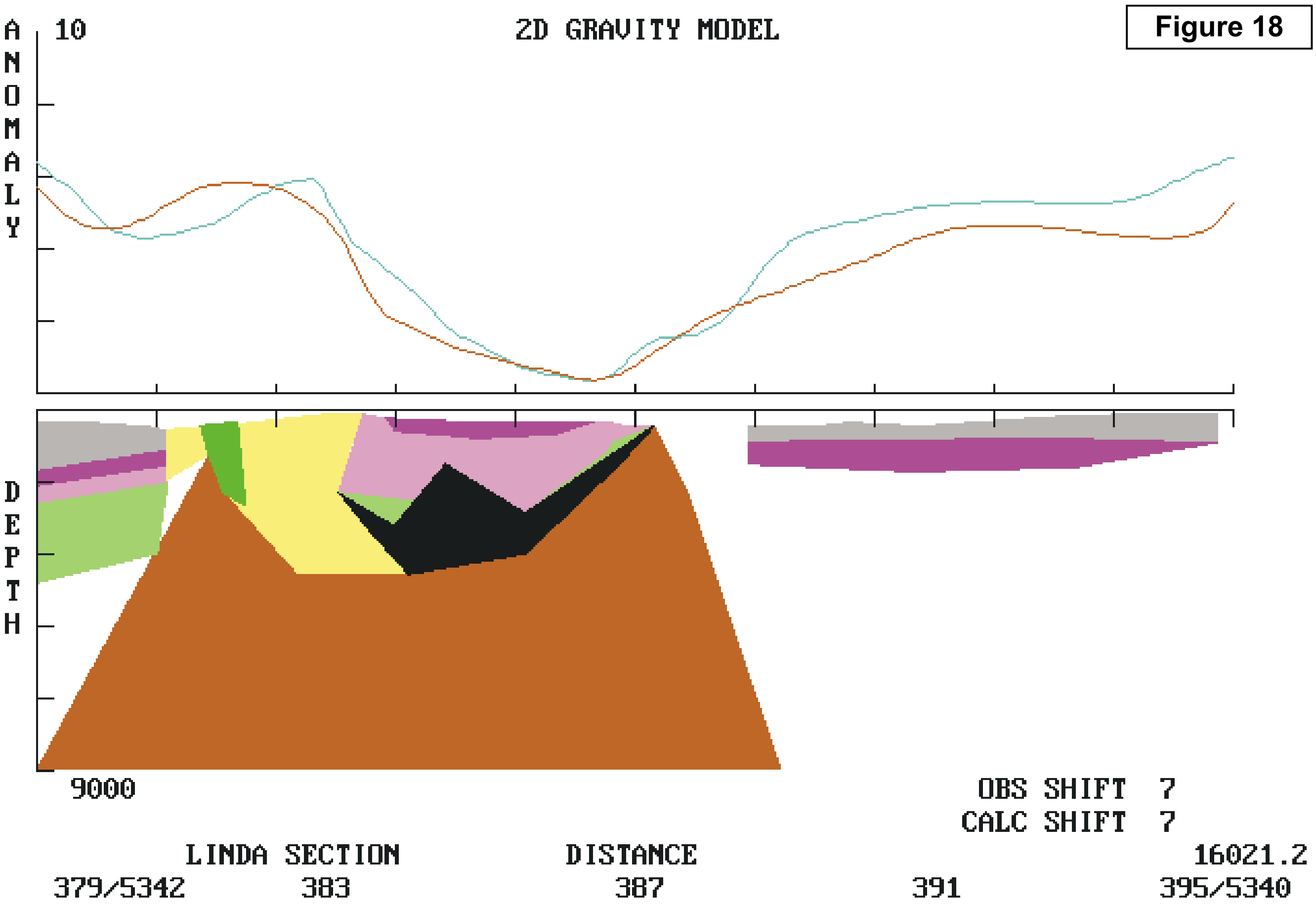


Figure 18

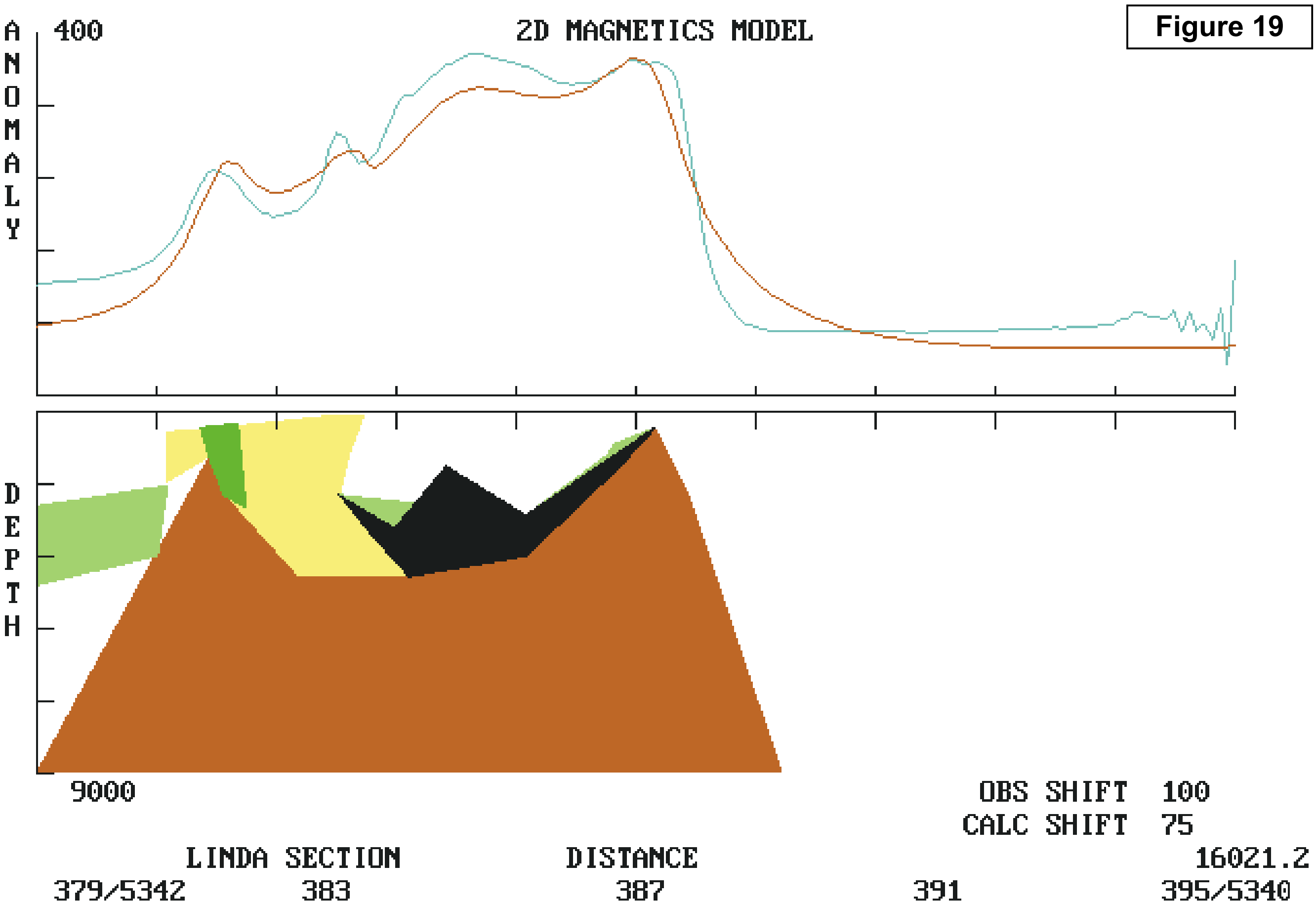


Figure 19

CAPE SORELL
350 000 mE/5 315 500 mN – 387 000 mE/5 291 000 mN

The Cape Sorell peninsula contains a complex structural assemblage in which most geological units trend northeast and are in faulted contact with each other. Some of these faults are inferred to be thrusts (Leaman, 1986*a* and recent survey maps) and others are of uncertain type. Unit relationships are not well understood. This traverse was selected normal to all structures in order to sample all units and assess possible relationships. It was felt that the implications, if deducible, would have regional applications.

Solutions are offered for this complex zone which show that Crimson Creek Formation rock equivalents are deep in the section to both the east and west but are structurally terminated near 365 000 mE by exposure of Burnie–Oonah equivalent Precambrian rocks. The older units thin coastward, as well as towards the Tyennan basement. It may be inferred that the basement extends beneath the entire peninsula and is at relatively shallow depth on the continental shelf. This would explain its presence above the shallow west-dipping thrust west of 358 000 mE.

All units, including Cambrian volcanic and volcaniclastic rocks and the Cambro–Ordovician Denison Group, thin towards Tyennan basement.

Gravity data cannot resolve the attitudes of structures within the complex but magnetic data define a central and critical structure at approximately 365 000 mE. A wedge of Precambrian rocks, partly overthrust, is incorporated in this zone. Structures west of it dip shallowly west, and structures east of it dip more steeply east, as defined by ultramafic content. An exception is provided near the fault block which introduces porphyries and andesites (approximately 373 000 mE). Bounding internal structures in this block dip steeply west; these elements are evident in Figures 21 and 22.

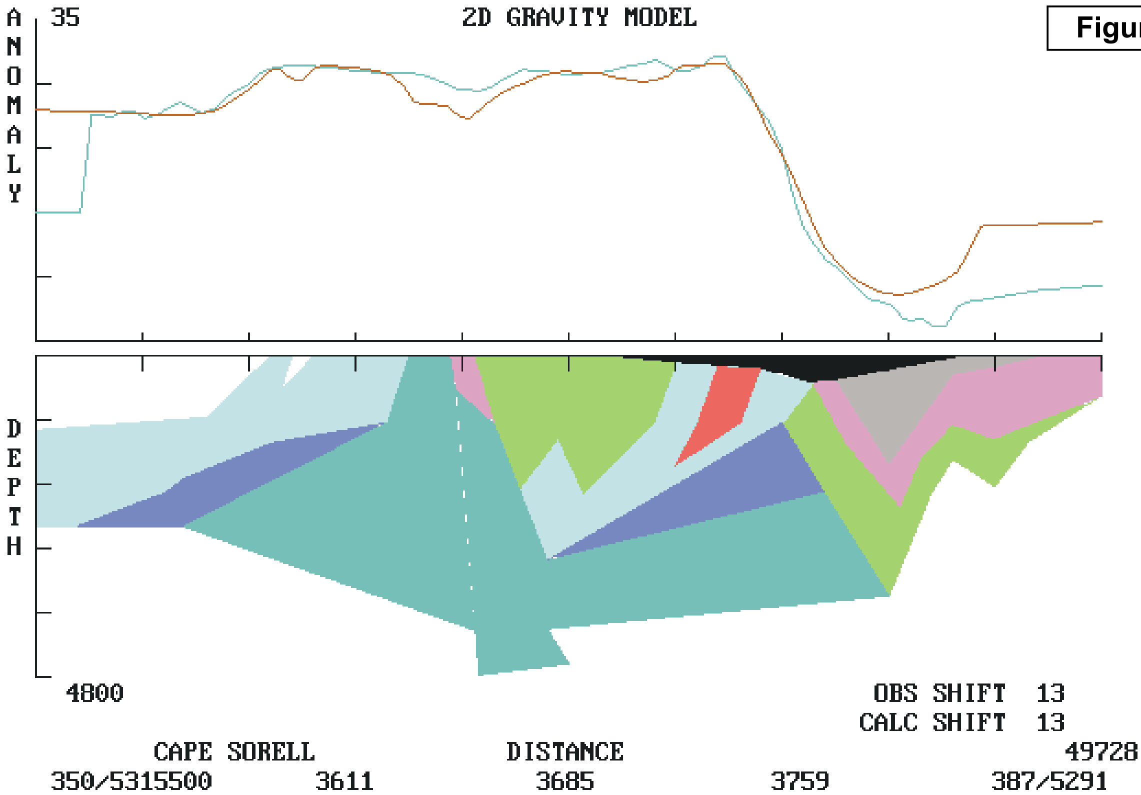
Tertiary basin development is focussed above the boundary between relatively thick Cambrian and Eocambrian rocks and their rapidly thinned relatives to the east (about 378 000 mE).

The gravity models also show that the large body of granite implied beneath the West Coast Range is also sampled by this line at its eastern end (compare fig. 20, 21).

Much more analysis is feasible in this complex zone but the present findings are generally consistent with Leaman (1986*a*) which was based on much poorer data. The problem of coverage remains; the gravity data base must be improved, and the magnetic data must be extended into the World Heritage Area if useful conclusions are to be obtained.

The 41 variants reviewed in this study combine to indicate involvement of several types of Precambrian rocks (including Oonah style), limited wedges of Crimson Creek Formation, and an overlay of Cambrian volcanic rocks which thin eastward, and are faulted. Ultramafic rocks are included in some faults, mostly east-dipping. A large pod of ultramafic rocks extends deep within the sliced zone.

Figure 20



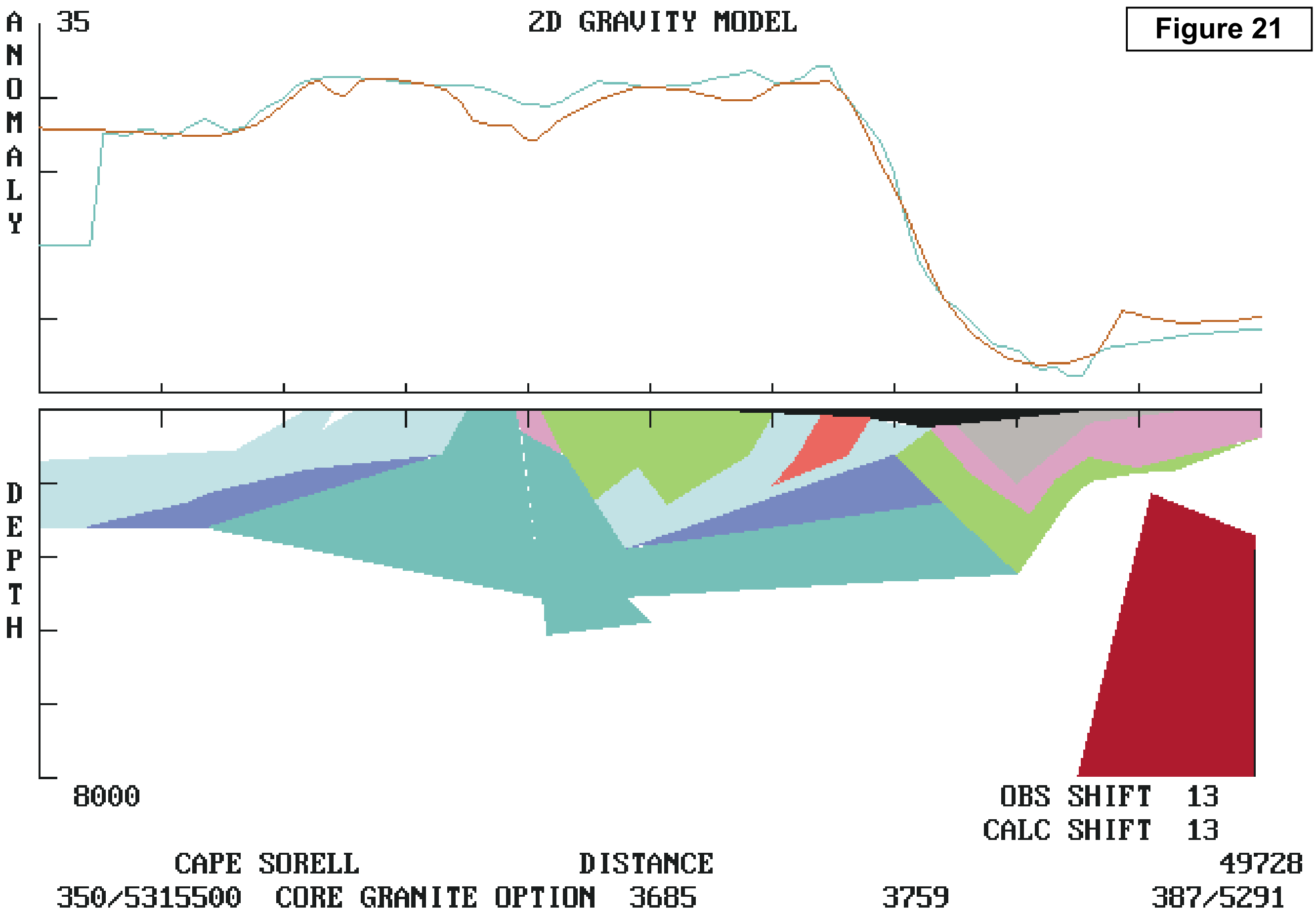


Figure 21

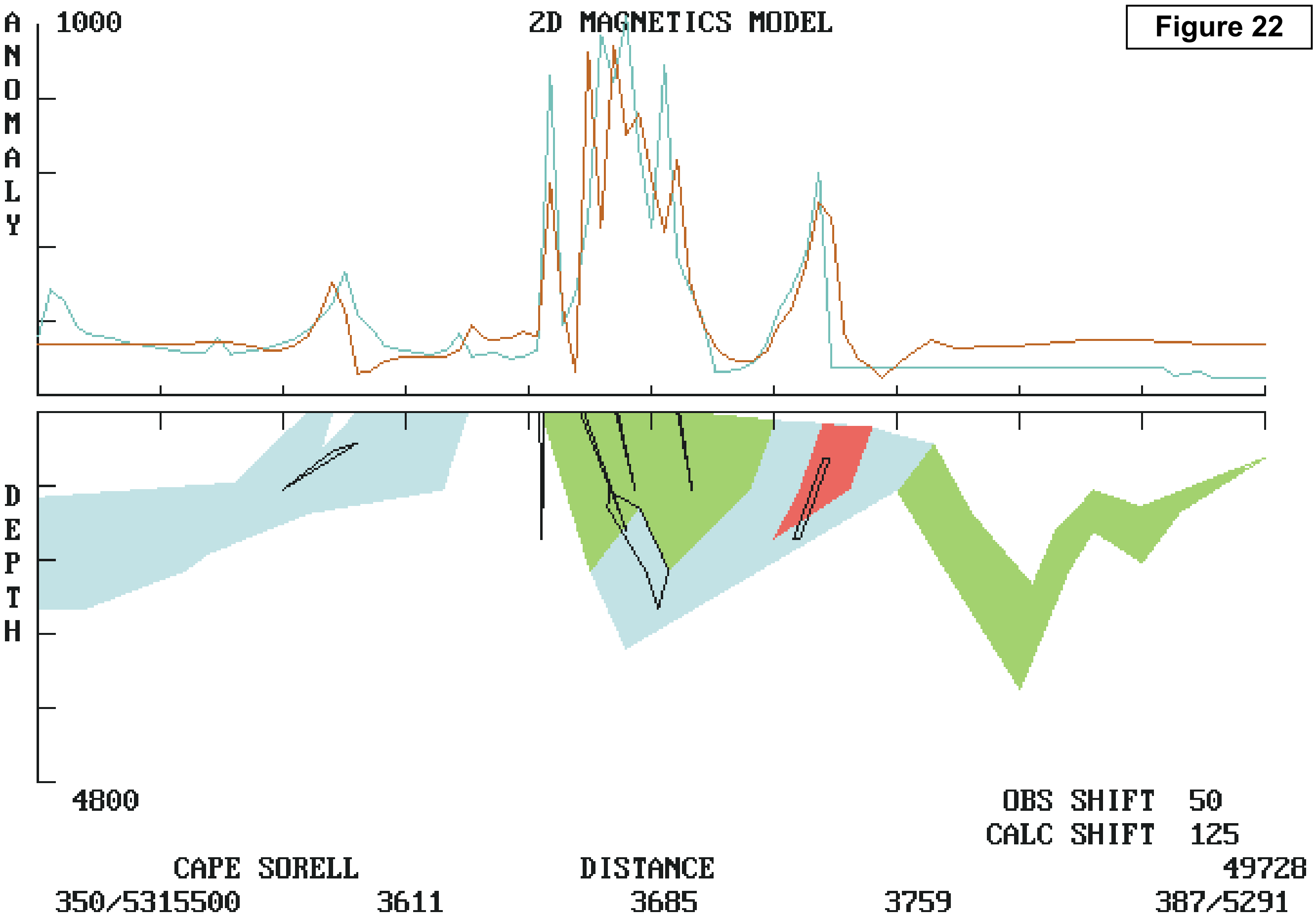


Figure 22

MT OSMUND
370 000 mE/5 252 500 mN – 390 000 mE/5 252 500 mN

This east-west section traverses at least three fault-bounded belts of Late Proterozoic to Early Ordovician rocks west of the Tyennan region which can be broadly correlated with sequences north of Macquarie Harbour.

The western belt consists of lithic wacke, mudstone and some mafic volcanic rocks and andesitic intrusions. Some rocks offshore at Acacia Rocks may be a Dundas Group correlate. The central unit consists of members of the Mainwaring Group, which may be correlated broadly with the Togari Group and the Crimson Creek Formation. The eastern suite consists of felsic volcanic rocks of Mount Read affiliation. Significant granite bodies crop out south of the section and a quartz-feldspar-biotite porphyry occurs to the east of the Mount Read Volcanics. The section also samples the south end of the Osmund syncline, cored with Denison Group. VHMS boulder deposits are known to the south but surface mapping provides little indication of boundary relationships.

The gravity model generally constrains likely volumes of most units but cannot adequately account for the anomaly amplitude (fig. 23). The gross gradient can be explained by the western belt of Mainwaring equivalents and a great change in sequence thickness across faults near 376 000 mE and 378 000 mE. The style and content of each sequence also changes in this zone.

The model cannot establish whether there is stratigraphic or structural overlap but it seems unlikely. The pod of porphyry to the east may be two kilometres thick. Gravity anomalies overall may only be satisfied by including a substantial granitoid at depth, mid section, beneath the axial faults — as required beneath the West Coast Range (see *West Tasmania* and *Cape Sorell* sections). See Figure 24.

Depending upon actual densities employed (2.62 t/m^3), the roof of this granite may reach the level of the volcanic section (which may be deposited on, or derived from, or intruded by it) but these parts of the model present density-volume trade-offs and cannot be unambiguously resolved. There is no possibility that the mass deficiency can be explained by the broadening fold in Ordovician rocks immediately north of the section. The possibility was reviewed and discounted.

The magnetic data are readily explained and do not resolve the depth range issues noted above. Ultramafic slices involved in the two large central faults west of the Osmund Syncline account for most character. No unit east of this zone is significantly magnetised. Parts of the lavas in the Mainwaring and Dundas groups provide the only other features (fig. 25). Mafic slices are either vertical or dip steeply westward.

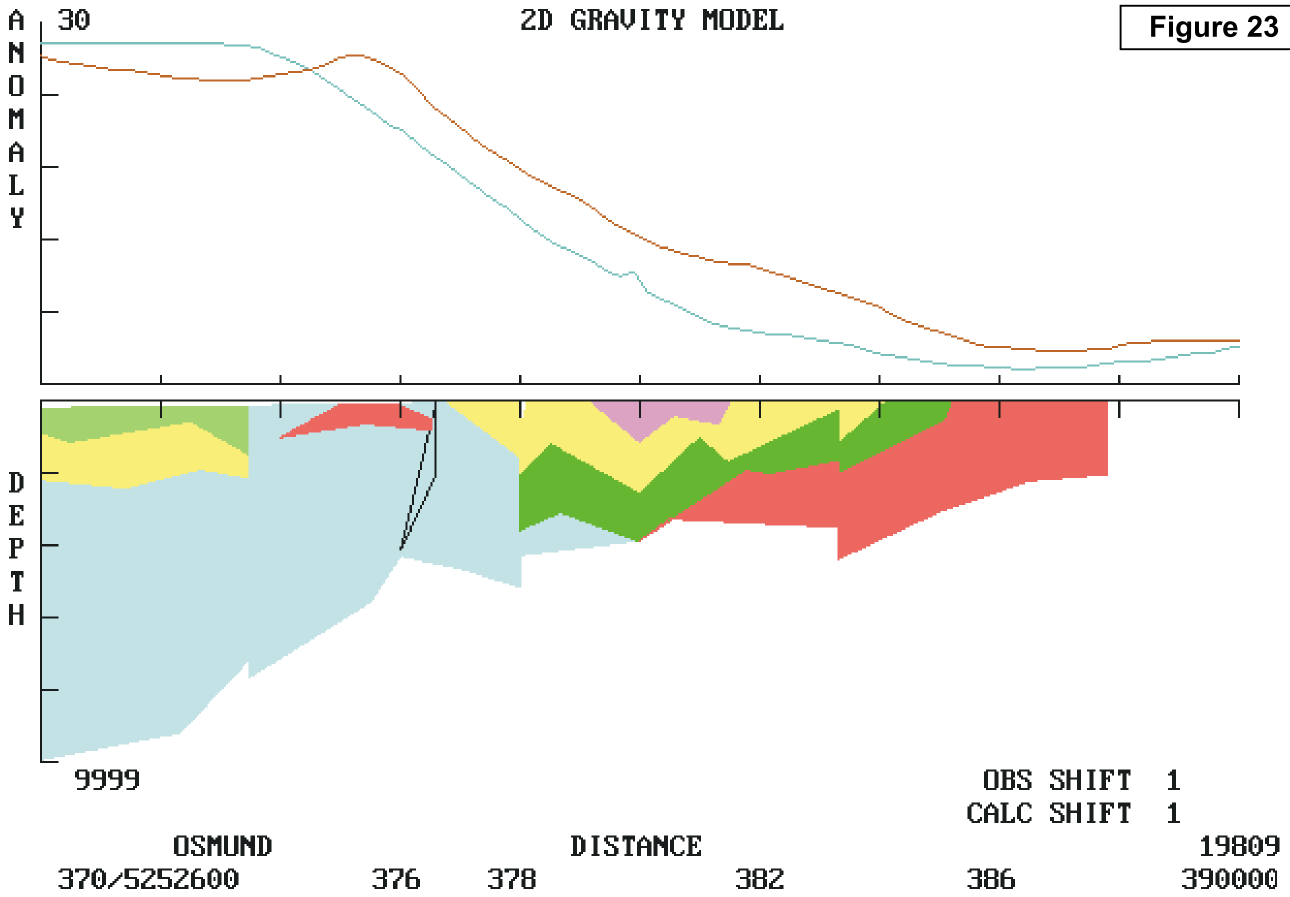


Figure 23

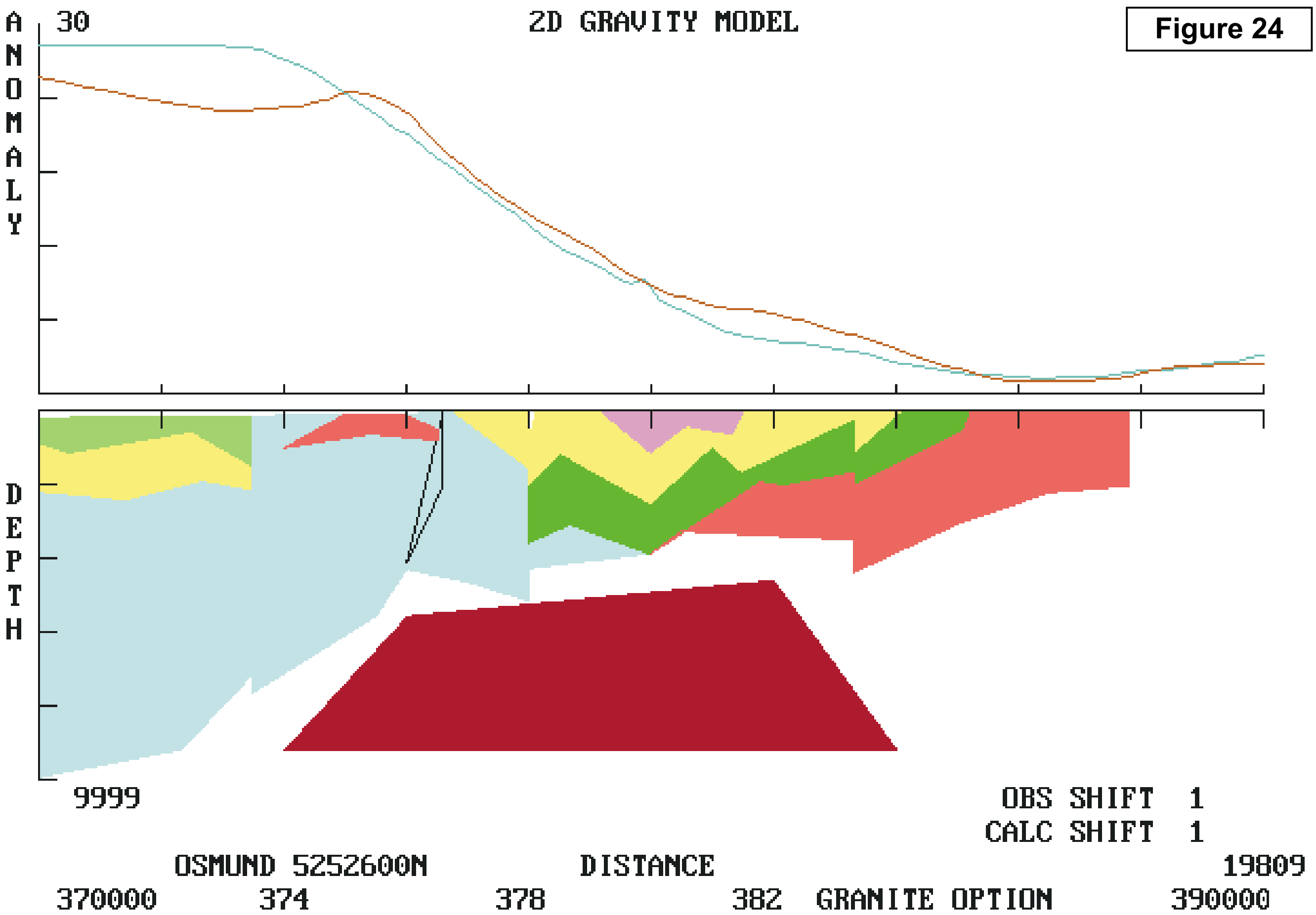


Figure 24

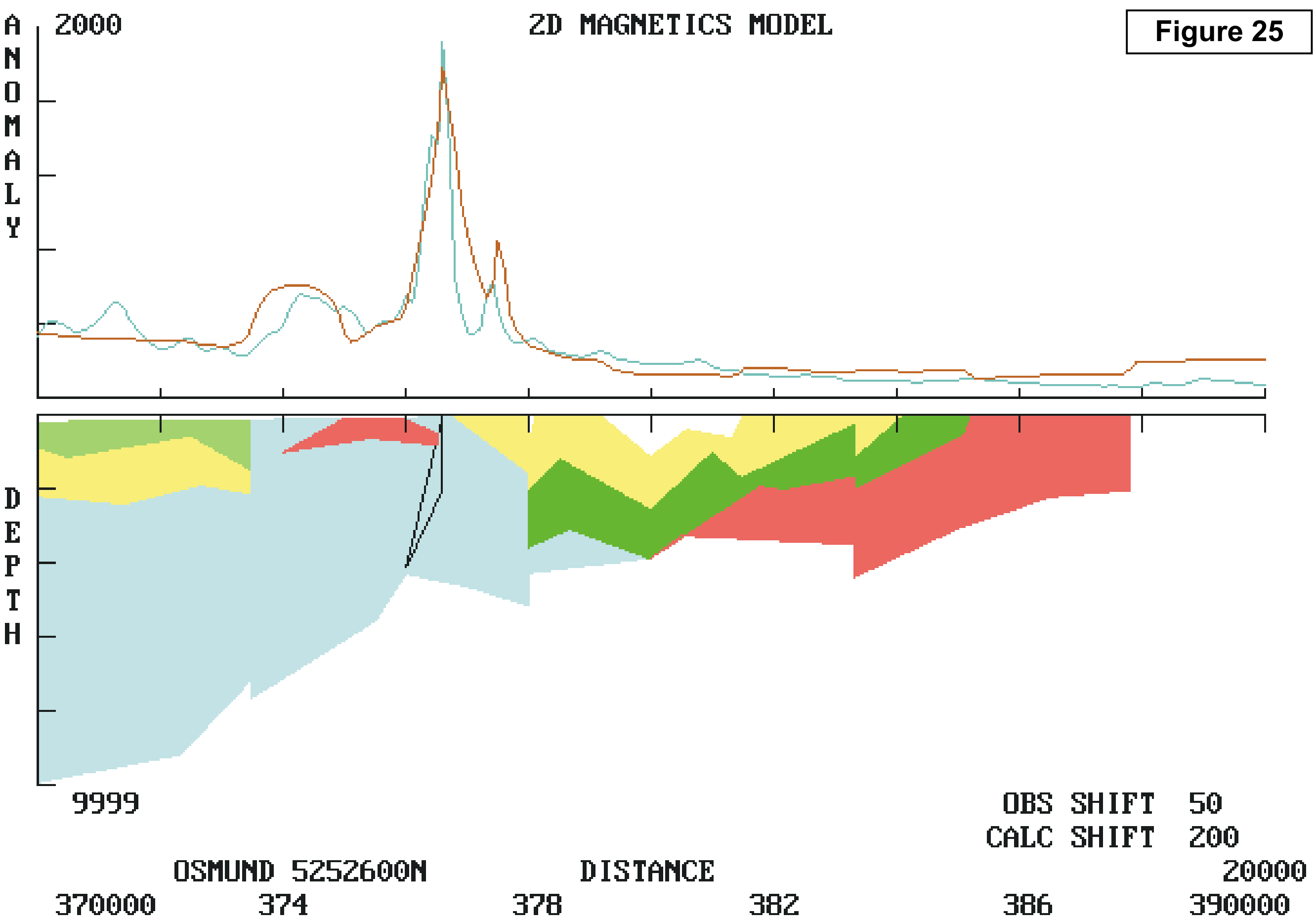


Figure 25

MEREDITH GRANITE – LAKE CETHANA
(Seismic Line East)
95AGS-T2: 359 000 mE/5 395 500 mN – 443 000 mE/5 401 500 mN

This profile, which approximates the northernmost section of the Berry study (Berry, 1997, see also *West Tasmania* section), was selected to test the interpretation of the TASGO seismic line and a number of other inferred relationships, including the eastern margin of the Meredith Granite, the Henty Fault, concealed granite bodies and volcanic rocks near the Hellyer mine.

The general style and content of line 5 396 000 mN of Berry (1997), and the current version of the 3D model for the extended Dolcoath Granite, were assembled to produce an initial model. Such a model is quite unlike any interpretation offered to date for the seismic line (e.g. fig. 28) which barely admits the existence of a large mass of granite in the region. After revision and adjustment this model was converted into the solution given in Figure 26.

The combination of elements generally satisfies the gravity data but the model requires a substantial thinning of the volcanic/volcaniclastic packages suggested in the Berry model in the region of the Henty Fault. The model also indicates that the volume of Cambrian granites is much smaller or that the properties overlap with consequent loss of resolution (see *West Tasmania* section). This does not affect the general solution either for this line, which cannot present any N–S granite axis, or the Dolcoath Granite. Many Cambrian units cannot be resolved individually at regional scale by geophysical means but many members of the sequence may be thin or absent between 380 000 mE and 392 000 mE. The mass distribution suggests a flower structure which may have been active since early Cambrian time. This would have generated a pattern of growth faulting and elevated blocks with reduced deposition. The flower would have involved the Mt Cripps, Mt Charter and Henty Faults.

The Dolcoath Granite was either intruded along, or terminated by, the Henty Fault Zone.

The most significant structure along this section lies east of 425 000 mE and dips shallowly east. A major thrust is implied, as Cambrian rocks overlie a slice of ultramafic rocks and this is clearly reflected in the magnetic data (fig. 27). The general elevation of the magnetic field between 373 000 mE and 396 000 mE indicates deep ultramafic rocks (average 3 to 4 km deep), or slices which form a virtual base for Cambrian rocks and which are essentially continuous. These are very difficult to model with any precision in a 2D section, especially when much of the material is off section. Two slivers of this material approach the surface near the eastern margin of the Meredith Granite.

The largest magnetic anomaly along the section is related to sources near the contact between Gordon Group rocks and the granite roof, which occurs at relatively shallow depth near 420 000 mE–425 000 mE. This is thought to be due to roof skarns. Most other magnetic features are related to patches of Tertiary basalt at surface.

The complete interpretation, with or without the wedge of Precambrian rocks which are known to occur between granite and Cambrian rocks south of the Cradle Mountain Link Road, necessitates a complete review of the seismic data. Figure 29 presents my interpretation of this data which recognises the subtle upward reflectors, the coherent ringing, and an estimation of surface velocities and time delays.

The continuity of the Precambrian rocks cannot be assessed because minor variations in the thickness of Cambrian rocks, or depth to granite roof between 400 000 mE and 415 000 mE, are not independently resolved.

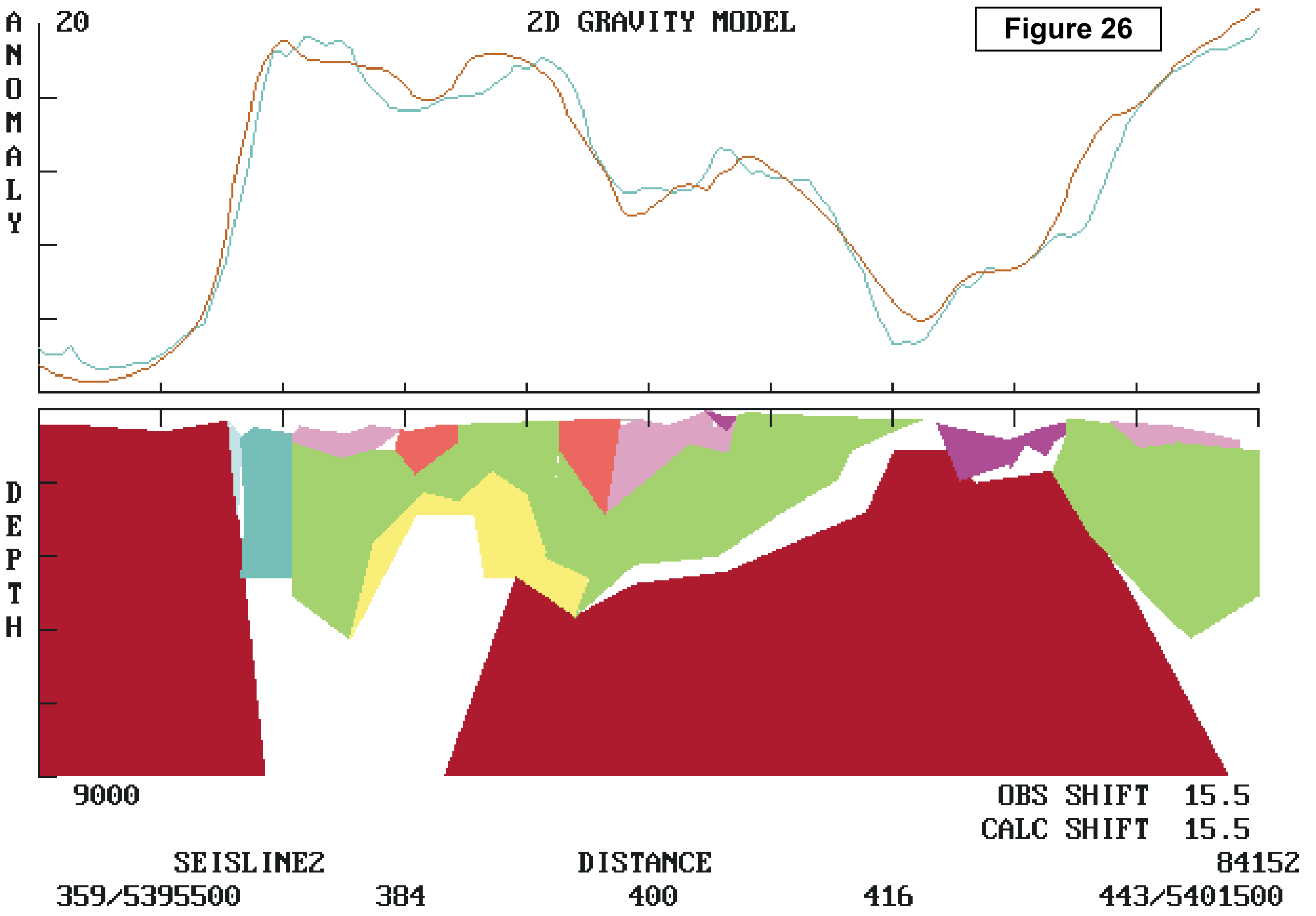


Figure 26
2D GRAVITY MODEL
ANOMALY
20
DEPTH
9000
OBS SHIFT 15.5
CALC SHIFT 15.5
SEISLINE2
DISTANCE
84152
359/5395500
384
400
416
443/5401500

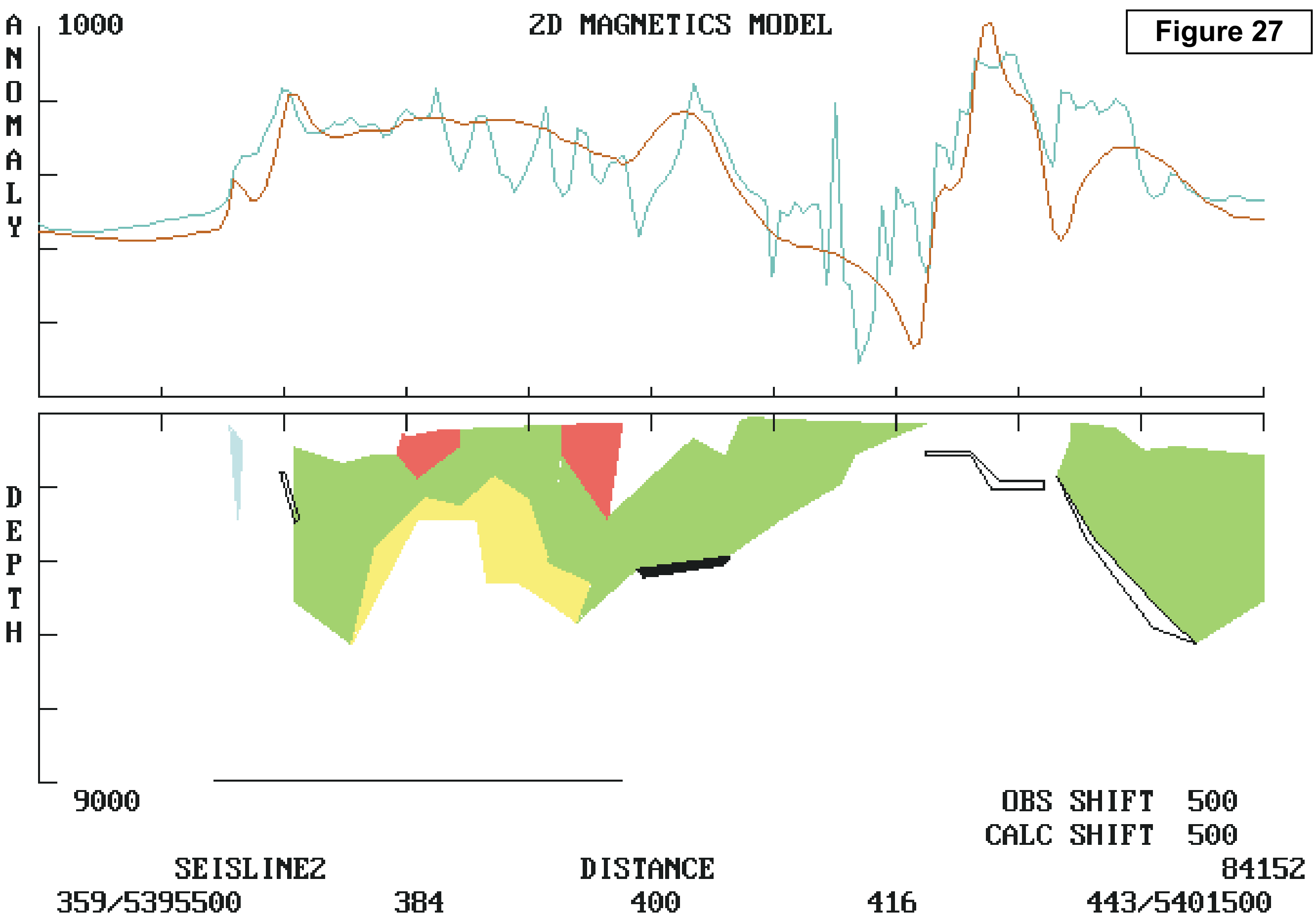


Figure 27
2D MAGNETICS MODEL
ANOMALY
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DEPTH
9000
OBS SHIFT 500
CALC SHIFT 500
SEISLINE2
DISTANCE
84152
359/5395500
384
400
416
443/5401500

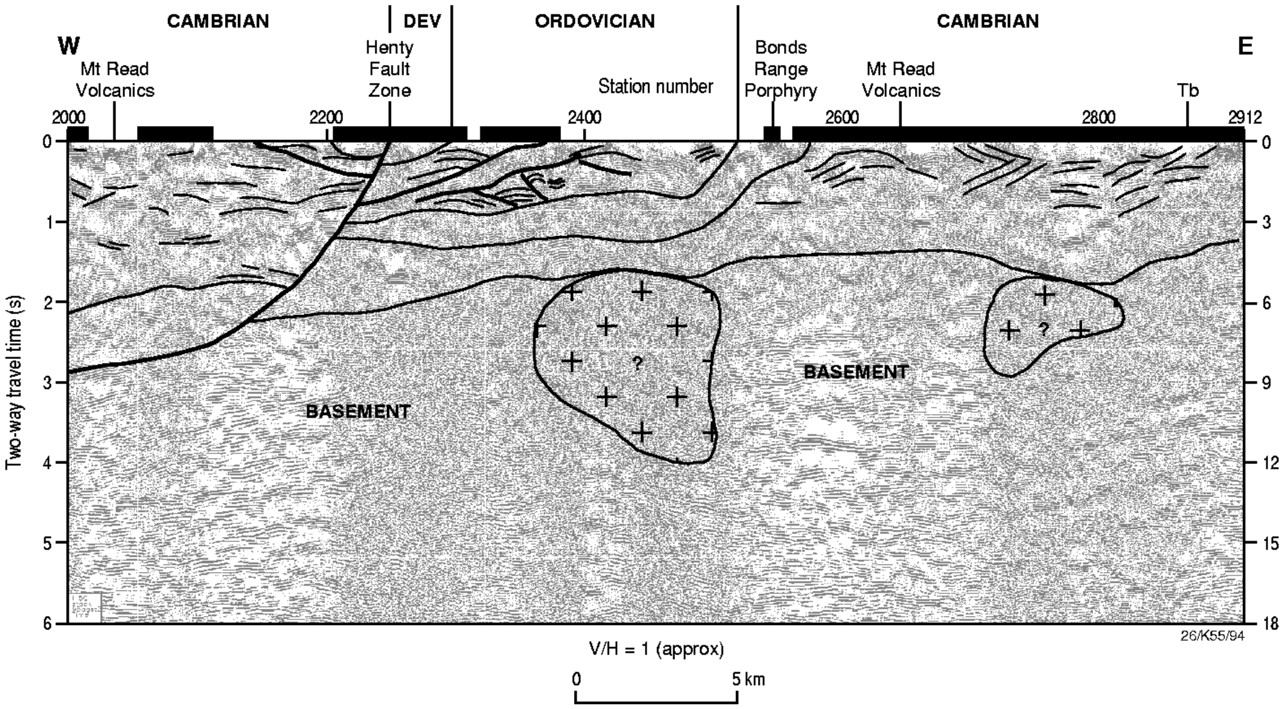


Figure 28

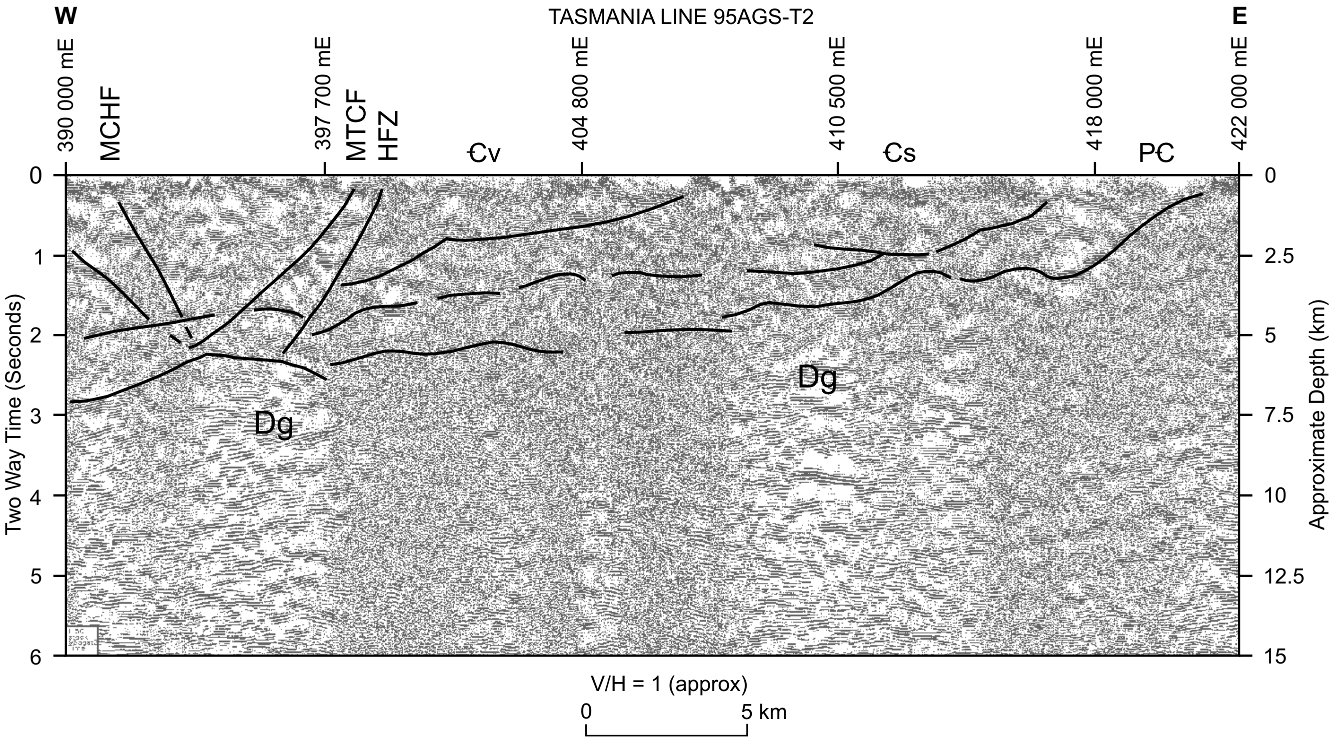


Figure 29

MACHINERY CREEK

425 000 mE/5 393 000 mN – 448 000 mE/5 441 000 mN

The Machinery Creek Fault is a major NW-trending, dipping fault in the Cethana area which has thrust Cambrian felsic volcanic rocks over Ordovician sandstone and limestone. The fault appears to have a growth/basin history as Late Cambrian–Ordovician conglomerates are thicker on the northeast side of the fault. The relationships between the various Cambrian units to the northeast of the fault are unclear and have been subject to complex folding and faulting. The traverse allows some review of each issue.

The profile provided is very difficult to analyse because of the very lack of control which it was drawn to assess. Folds, offsets and cover northeast of the Machinery Creek Fault clearly require 3D analysis and an extended treatment. The control section used to construct ideas for the model was bent in order to provide clear sampling of structures in the Lake Barrington area. The profile examined is straight and passes in and out of fold axes and the eastern limbs of large folds.

Within these limitations it is possible to offer some findings. Gravity data have again been used to constrain total section volumes and show that the fault zone is both complex and stacked. The greatest thickness of Cambrian rocks occurs about 5 km north of the fault's surface presentation. Units are folded into the fault zone and offset. Near 440 000 mE a large syncline involving Ordovician rocks must reach, or approach, Precambrian basement. This would imply either significant Cambrian folding, or later dislocation, or both. The general basement is of Tyennan–Rocky Cape type. The sequence is thickened or doubled towards the east end of the profile.

The gravity data (fig. 30) are less ambiguous in dealing with the prominence of the Dolcoath Granite and the nearby Cambrian granites.

Both gravity and magnetic data indicate that the Cambrian granites, as magnetic entities, are small (fig. 31).

The magnetic data are surprisingly simple in character overall and present smooth features, which indicates deep and often intense sources. Minor deviations can be related to units in the volcanic sequences or the local andesites but the broad effects are not associated with any exposed material.

Resolution of the magnetic profile requires three unit types; fairly continuous slices of ultramafic rocks at the base of the implied Cambrian volume (at least east of 436 000 mE); east-dipping slices of ultramafic rocks within the elements of the Machinery Creek Fault complex; and an intense source beneath the Ordovician rocks at Lake Cethana near the roof of the granite.

A substantial local skarn is indicated. The skarn anomaly is not readily modelled in a single section but its shape is very irregular and the source may approach the surface.

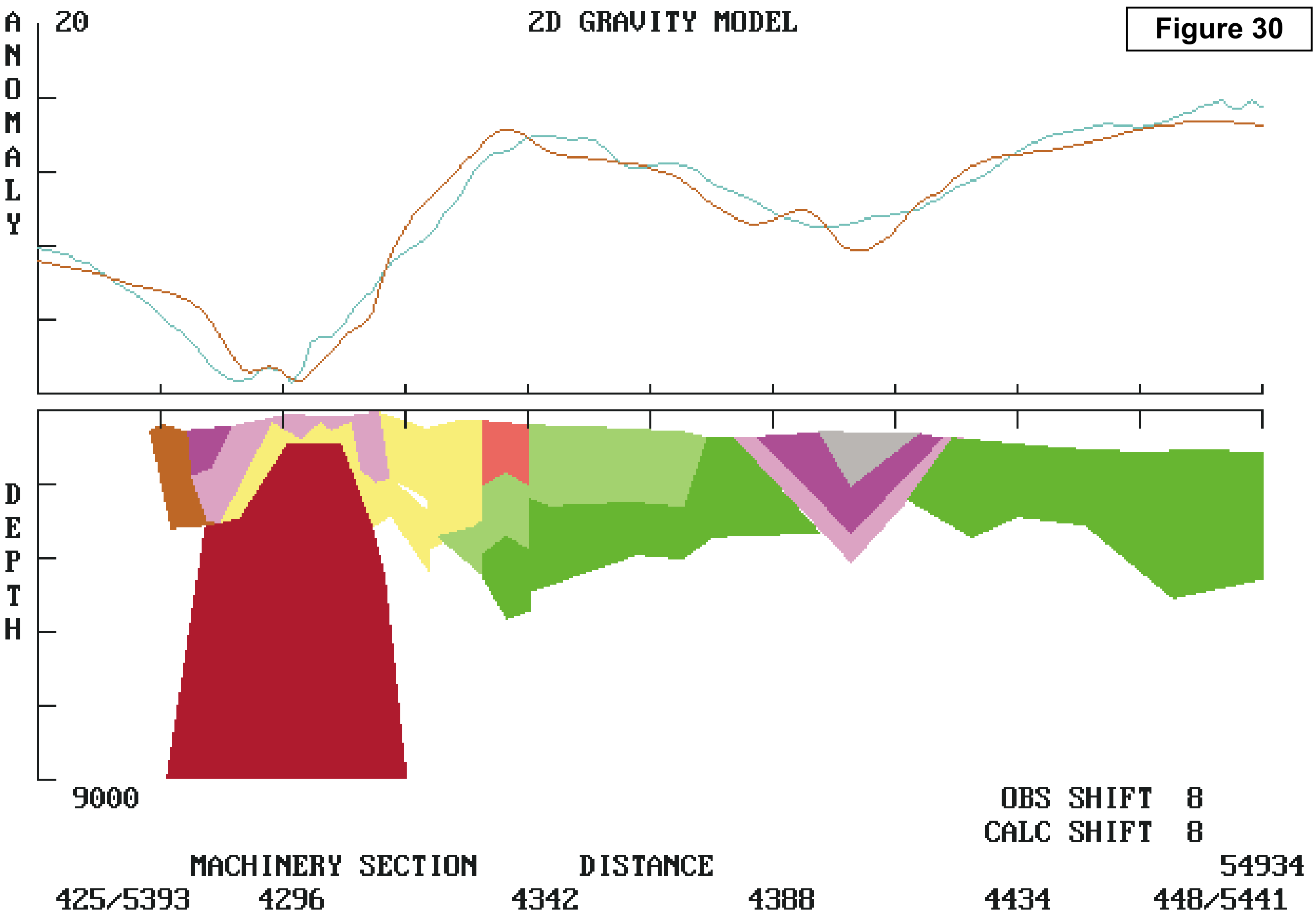


Figure 30

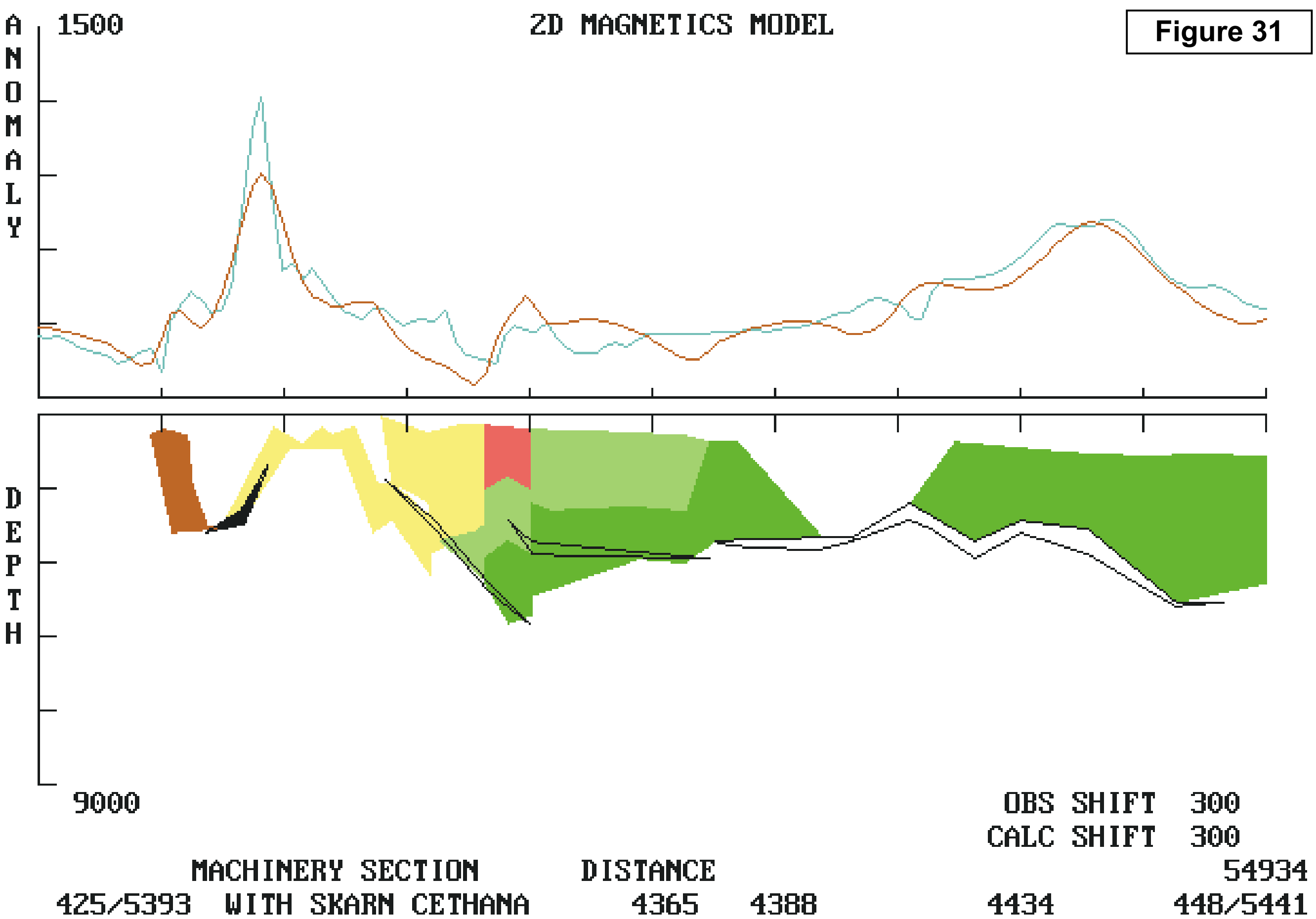


Figure 31

DIAL RANGE

367 000 mE/5 475 000 mN – 455 000 mE/5 433 000 mN

A long line transect was proposed between Rocky Cape, the Dial Range and the Forth Metamorphic Complex. The transect requires consideration of the Arthur Lineament and various deep ultramafic bodies. Inferences from such a transect may assist appraisal of offshore seismic data recently acquired under the TASGO Project.

Issues of structural style, granites, Dial Trough, ultramafic rocks, basement blocks and the Arthur Lineament are integrated into a single section. No long line geophysical modelling has ever been reported previously which might aid this assessment. There have been some limited partial treatments.

(a) *Sheffield east* (Leaman, 1991*b*). This limited study suggested major overthrusting from the east with major dislocations at the easting of Latrobe (see also *Badger Head* section).

(b) *Dial Range* (Leaman, 1986*b*, 1987, 1993; Leaman and Richardson, 1989; LeClerc, 1996). Most previous studies have considered the role of granite within the structure and determined that the roof of the Housetop Granite is locally very shallow and clearly related to aspects of local mineralisation. There has been no regional treatment of the 'trough' itself. LeClerc (1996) demonstrated that portions of the Housetop Granite are underlain by ultramafic rocks and have been overthrust or dislocated. The anomalous location of the Dial Range structures and sedimentation was described by Leaman (2001).

The Dial zone has also been considered by Woodward *et al*. (1993) who have generated balanced cross sections which suggest east-dipping thrusts involving the Forth Block to the east, and west-dipping thrusts which involve Burnie Formation to the west. This assessment may be valid at shallow depth but the balancing must be doubtful at depth in a Cambrian sequence as variable as that found in northern Tasmania. Further, their model ignored the effect of the granite on later structuring or even primary controls on the intrusion of the granite in the first instance. Figure 32 indicates the possible role played by the granite in structual control if one assumes that much of the late thrusting post-dates the intrusion, or is even contemporaneous. Their conception of structures from the Tyennan Massif to Badger Head suggests major detachments involving Cambrian and Precambrian rocks, some truncation of these systems by Late Cambrian erosion (see also *Gog* and *Machinery Creek* sections) and reactivation. Woodward *et al*. (1993) consider east-facing structures extend east of the Dial axis (see also *Badger Head* section).

(c) *Arthur Lineament*: Leaman (1986*a*, *b*, 1990) and Leaman *et al*. (1994) have provided some geophysical reviews of the northern section of the lineament. These studies demonstrated that significant property contrasts occur across the belt and Leaman (1990) suggested a complex tight fold of Togari Group rocks overthrust by Rocky Cape Group south of Wynyard.

The new compilation provides a general picture.

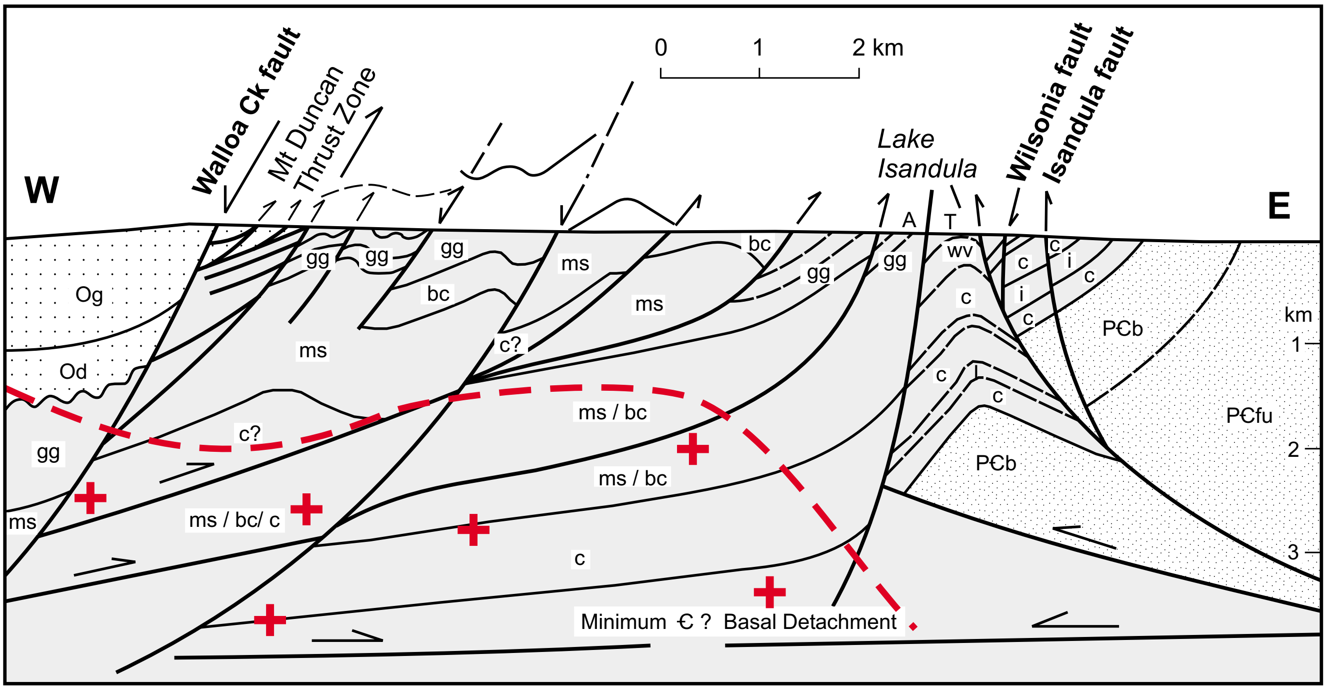


Figure 32

Possible role of granite in structural control on the model of Woodward et al. (1993)

The Arthur Lineament is about 10 km wide (about 390 000 mE) but is depth limited whatever shape, form or origin is assigned to it. The contrasts cannot persist to depths much greater than five kilometres at Wynyard (fig. 33) although the deeper form could be seen as detached, tightly folded or a structurally altered slice. Earlier work by Leaman (1986*b*) indicated that the depth limitation might be seven kilometres further south. The dip of the zone is not reliably resolved with the present data or a single section but appears to be very steep (more than 70° and probably to the east).

The general volume of Housetop Granite (about 410 000 mE) is suggested. There are roof spines as indicated by earlier work but the long line cannot resolve such details clearly.

The distinctive feature of the gravity model is the change in character associated with the complex zone of deformation which is exposed west of Ulverstone (about 430 000 mE). This zone dips east and anchors a number of other, more shallow detachments which dip east. All involve Cambrian rocks and various types of Precambrian rocks. The style is a more complex version of Woodward *et al*. (1993).

The Dial Trough is seen to be nothing of the sort, but a structural wedge block caught between large pieces of Burnie Formation with bounding structures which dip west. The chaotic zone at Ulverstone is thus a fundamental boundary between east and west-dippipng structures.

The magnetic data (fig. 34) reinforce these conclusions by defining the locations of many ultramafic bodies (thin slices). Some are associated with the east face of the Arthur Lineament, both (!) faces of the Dial wedge of Cambrian volcanic rocks, the main chaos boundary and several of the eastern blocks. The attitude and general depth of all eastern structures is well constrained. Several blocks are coated by ultramafic rocks on their deepest face as discussed in the *Gog Range* section. No such bodies appear within the main body of siliceous basement rocks at either the west end or centre of the section.

The Forth Precambrian complex is included in these structures and again shown to be of distinctive composition and origin. It is also depth limited.

Several of these issues have been reviewed by more detailed modelling of parts of the profile.

WYNYARD SECTION (367 000 mE to 403 000 mE) (same alignment as main Dial profile)

More detailed gravity modelling provides some further constraints on the lineament, data limitations notwithstanding, and the west face may dip steeply west. More data are needed and a refined constraint on the surface projection of the lineament into the region. It is concealed locally by Tertiary materials.

Magnetic data show that elements of the structure either lie within the Rocky Cape Group or beneath it. One such feature lies north of the large shear (382 000 mE) at Two Sisters (also gravity response at moderate depth). All features can be reconciled if at least three members of the lineament complex are overthrust by a structure which also includes some mafic material. All sources must be very shallow at the lineament face if the sharpness of observed anomalies is to be matched.

These elements are best seen in the magnetic aspects (fig. 36 and 37). Figure 36 shows that, if the boundary of the lineament has been mapped properly, then several units lie outside it and that these must extend to very shallow depths. The implication of the gravity model and the slight magnetic effect near 380 000 mE shows that an additional deeper element is present, is truncated, and does not approach the surface. Figure 38 has the style of Leaman (1990) and it may be that the inferred detachment cuts more deeply further south.

The magnetic data also imply a significant pod of ultramafic material deep on the Burnie side of the lineament. These may mark a structurally-controlled base for the lineament rocks.

PENGUIN SECTION (416 000 mE to 438 000 mE) (same alignment as main Dial profile)

Although gravity data are sparse along the line (fig. 39), at the coast the model is able to offer some refinement of the regional view. The Penguin–Dial Range portion includes a significant extension of the Housetop Granite as inferred in previous work and this accounts for the mass deficiency (compare fig. 39, 40). The Dial Range Block is limited in volume and depth but is not intruded by the granite at this northing and the shallowness and multiplicity of structures east of Ulverstone (428 000 mE) is evident.

Magnetic data confirm several of these implications, especially east of Ulverstone. The detached character of the Dial Range is not confirmed due to the involvement of the granite but a basal relationship with ultramafic rocks is established. This may reflect detachment or an original basement upon which the volcanic rocks accumulated (see also Leaman, 1994*b* for other sites of this type, especially Figure 4).

Anomalies west of Penguin (approximately 421 000 mE) are related to faulted Precambrian rocks and ironstones — a source which extends the entire depth of the Dial Block with a wedge of Burnie Formation wedged between. This indicates a complete dislocation of the west side of the Penguin zone and, presumably, the Dial Range Block.

Figure 33

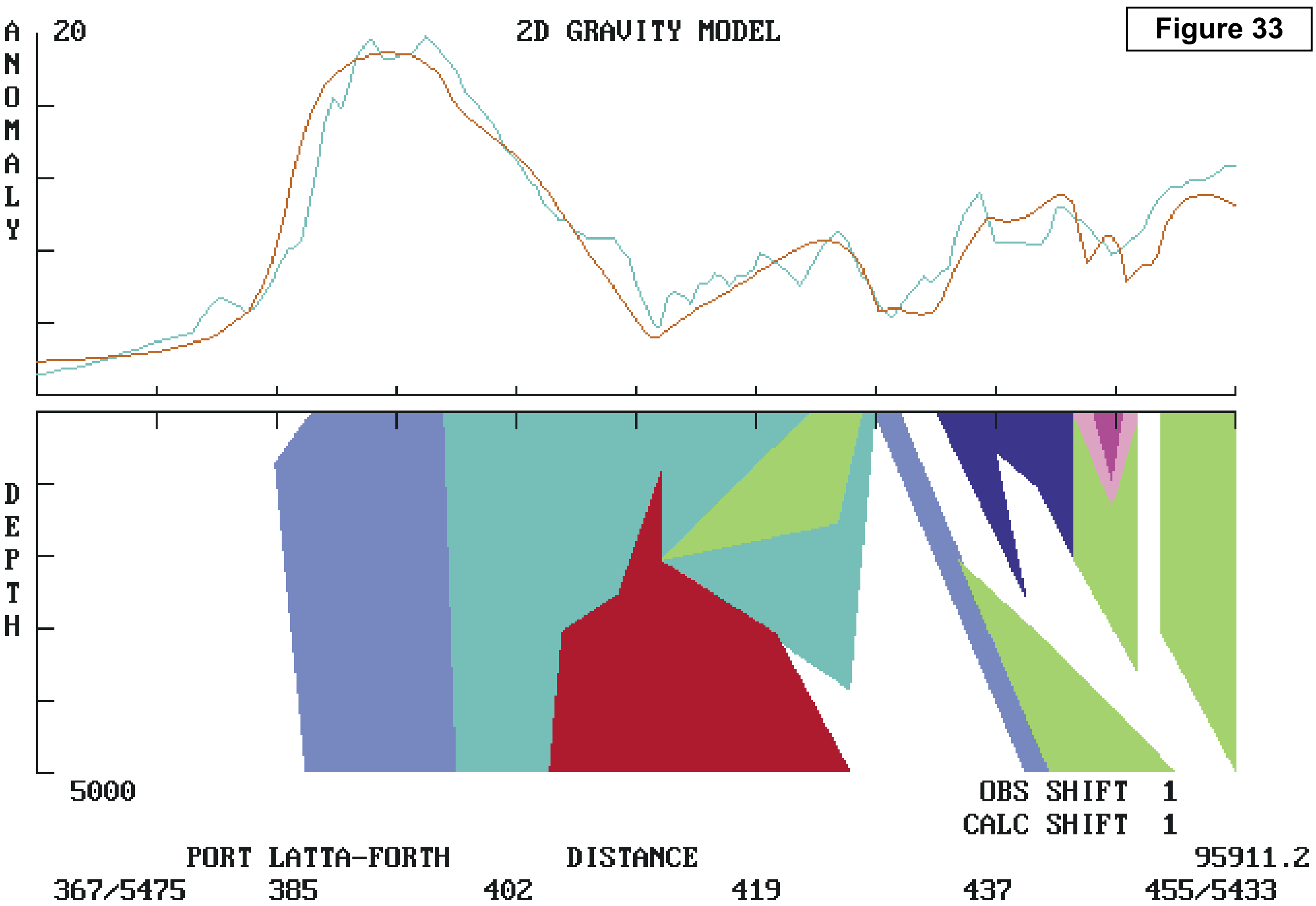


Figure 34

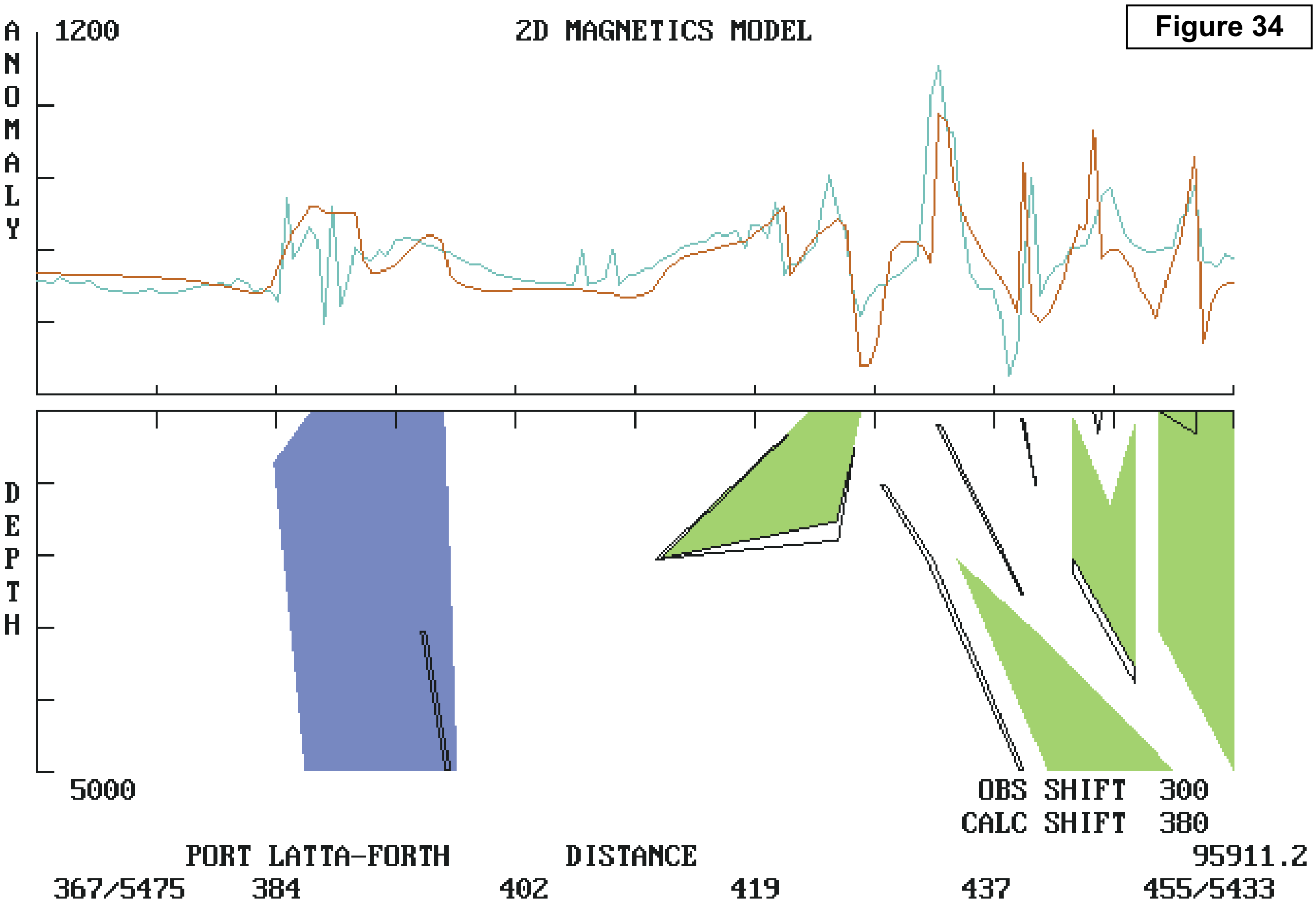


Figure 35

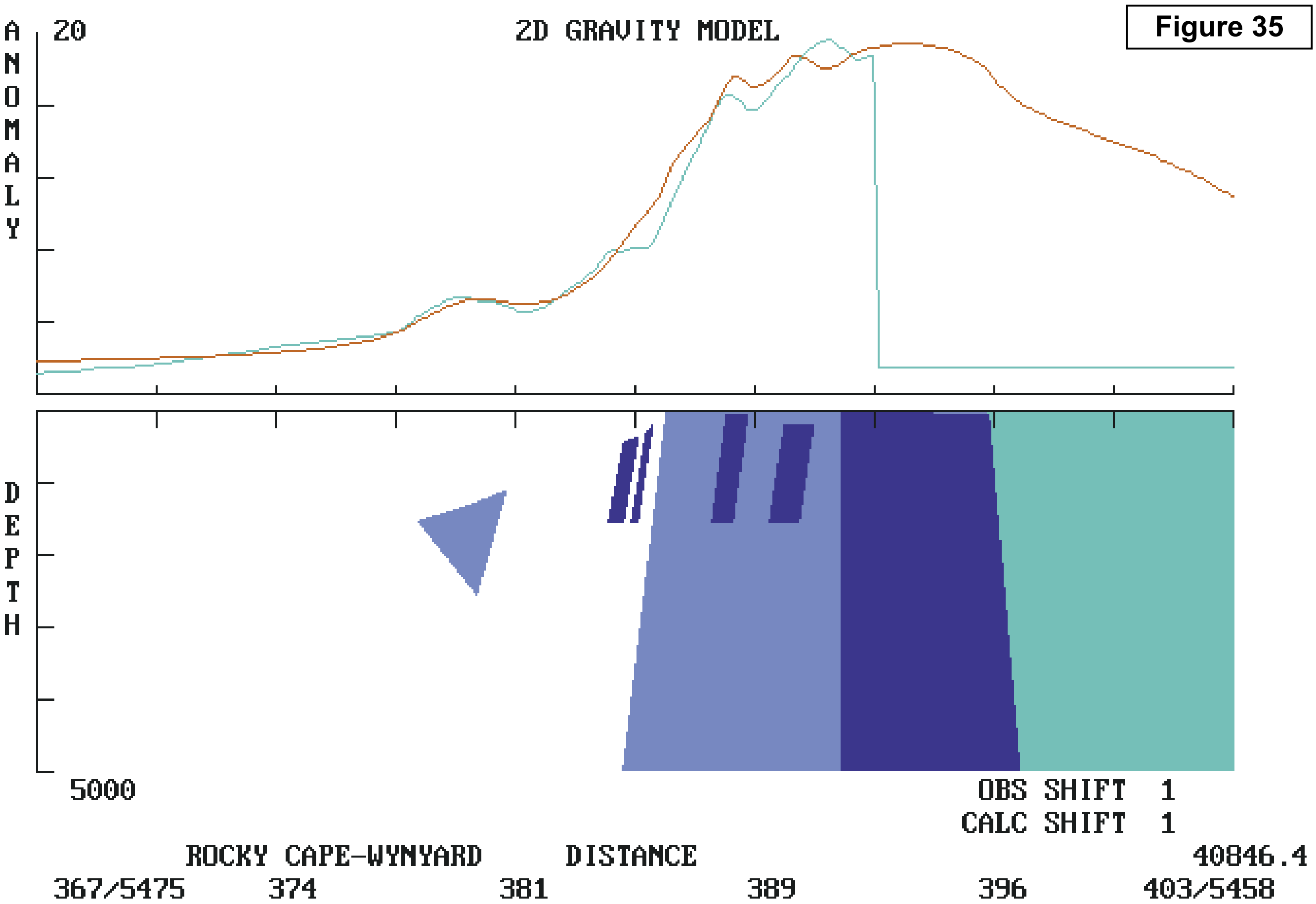


Figure 36

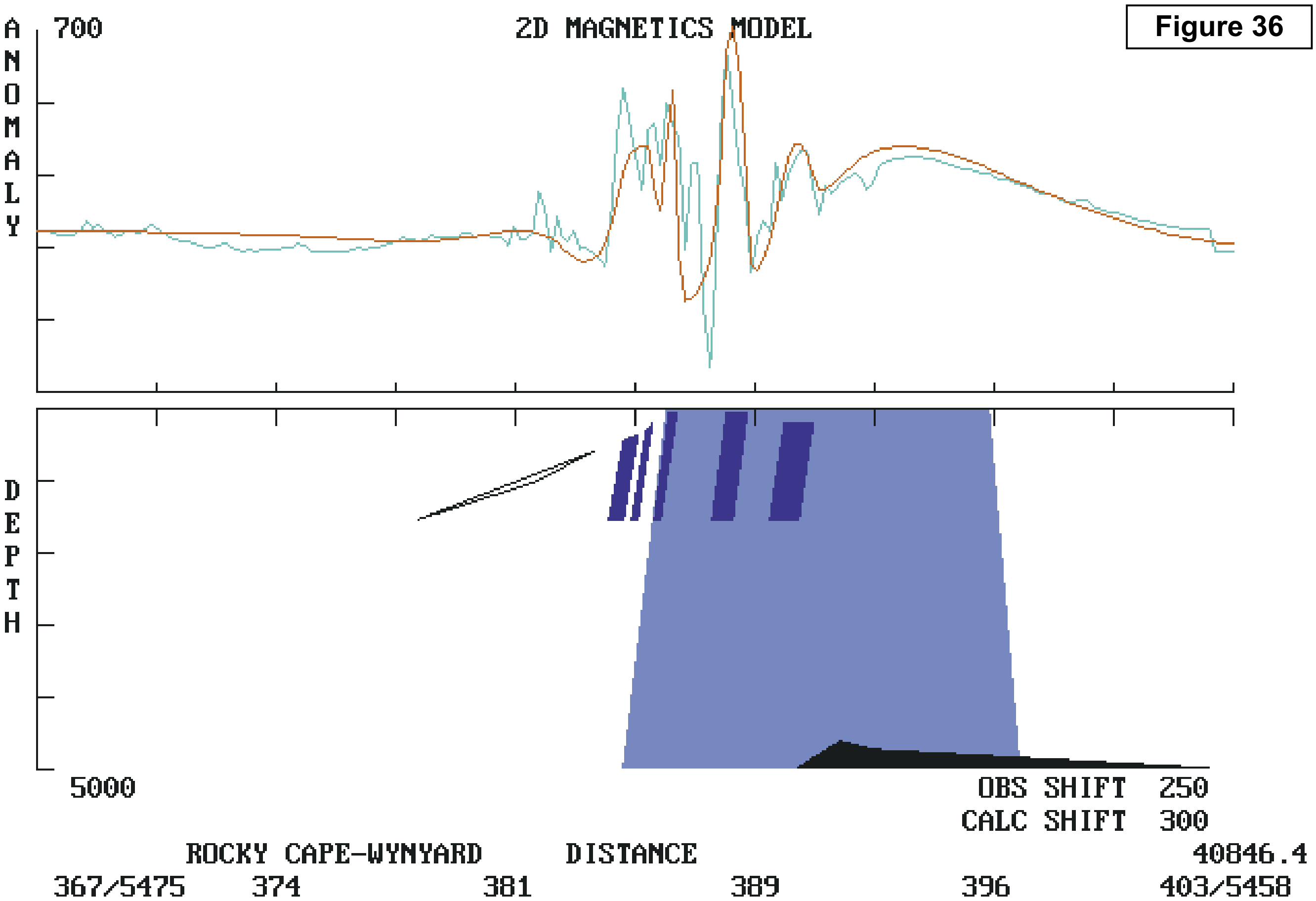


Figure 37

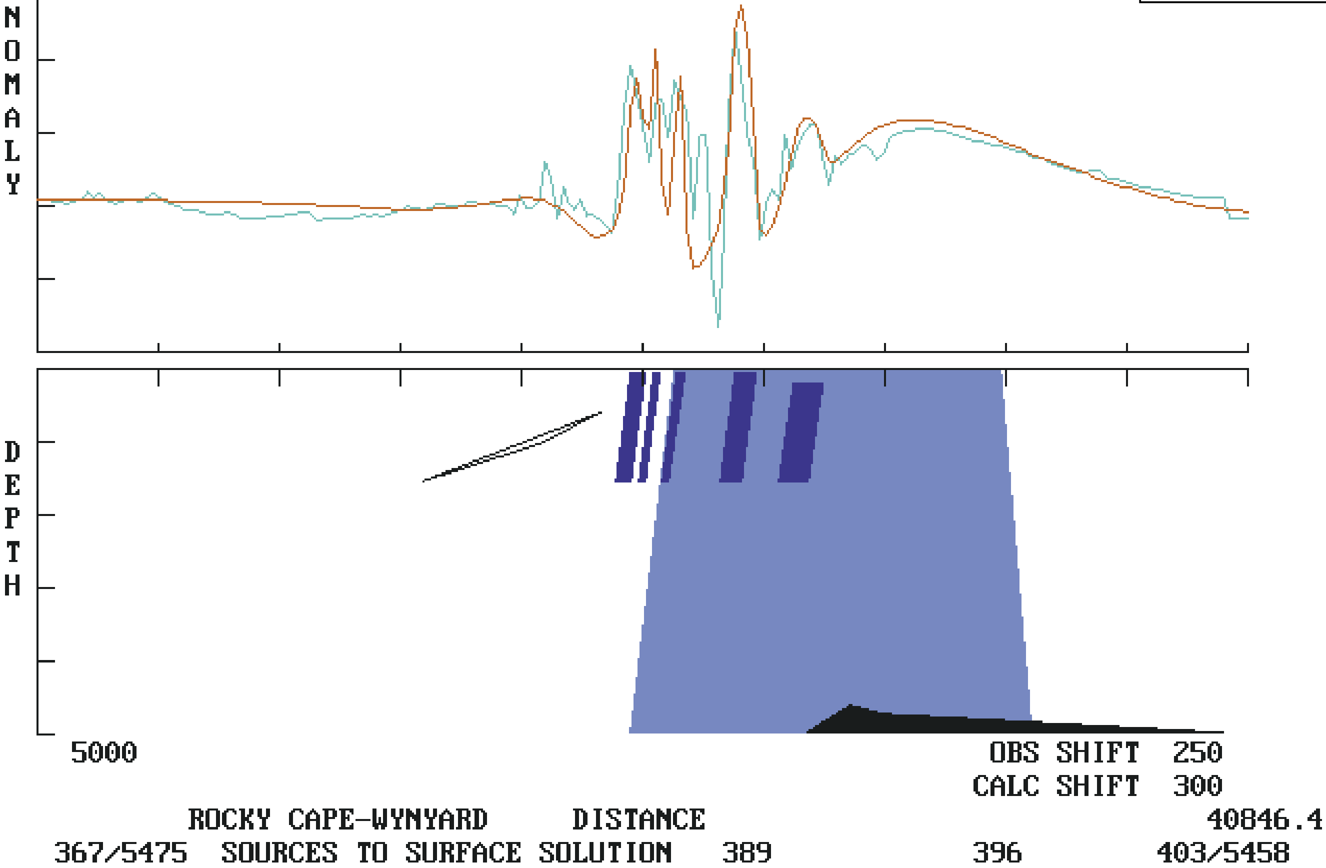
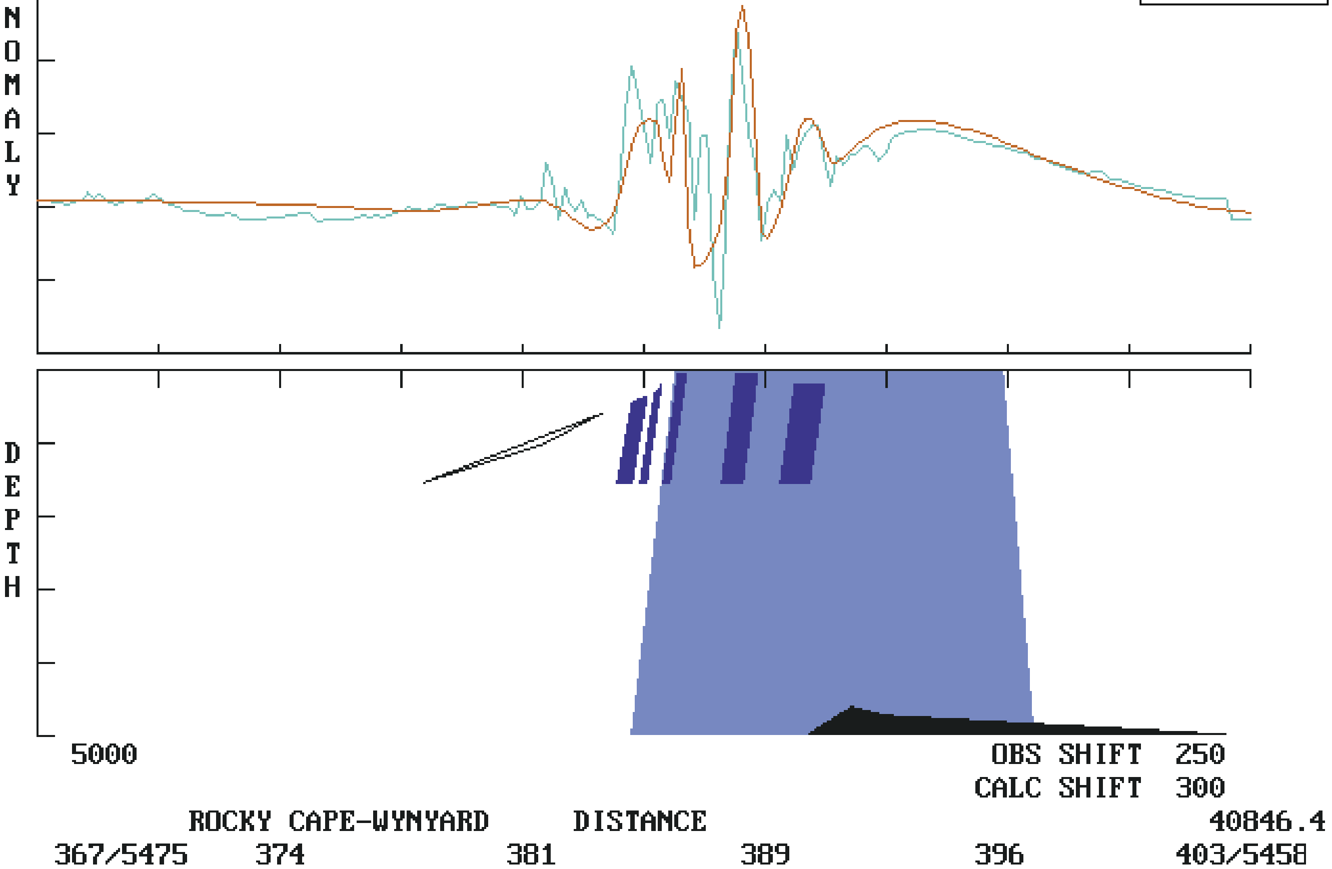


Figure 38



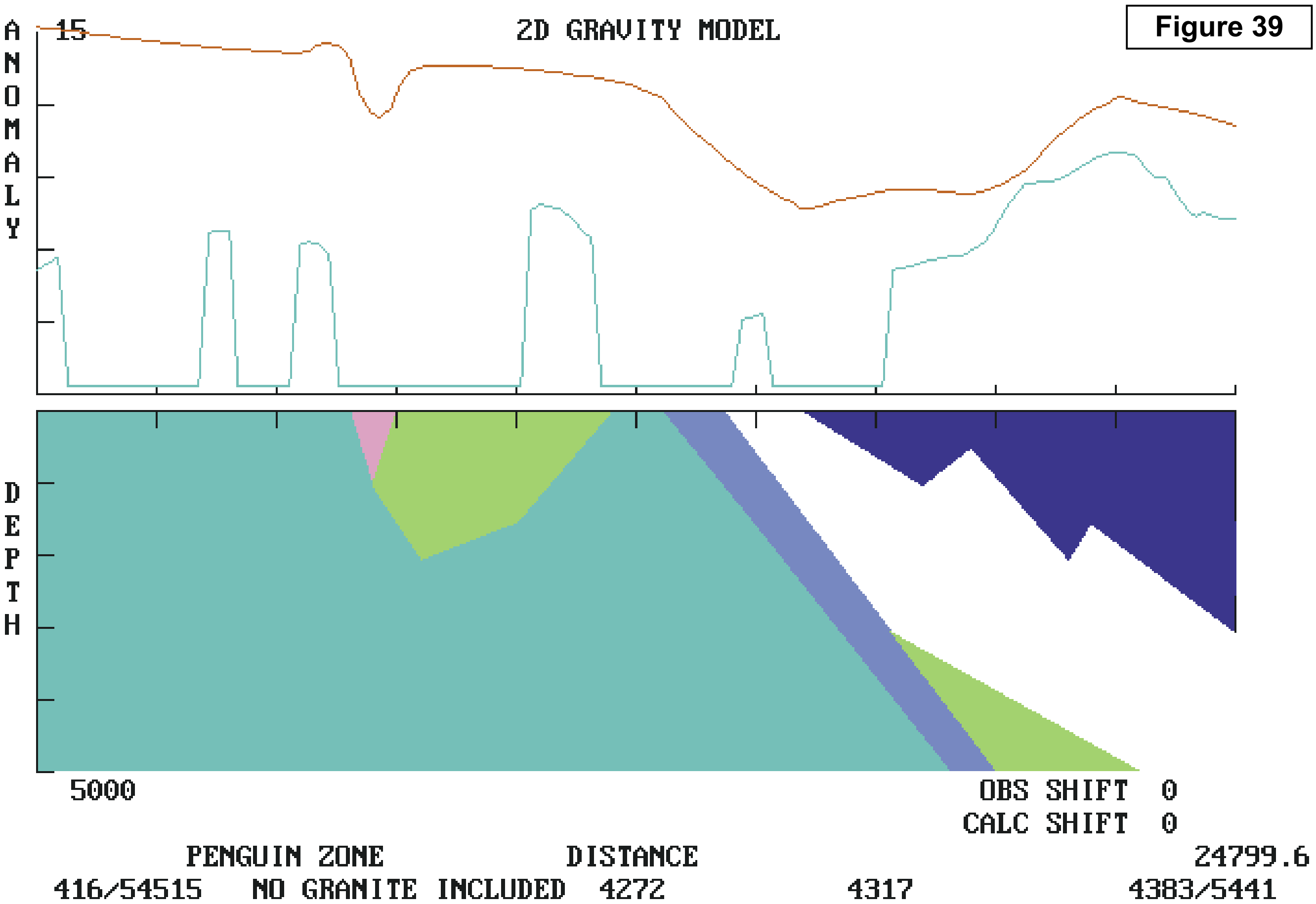


Figure 39
ANOMALY
15
2D GRAVITY MODEL
DEPTH
5000
OBS SHIFT 0
CALC SHIFT 0
PENGUIN ZONE
DISTANCE
24799.6
416/54515
NO GRANITE INCLUDED
4272
4317
4383/5441

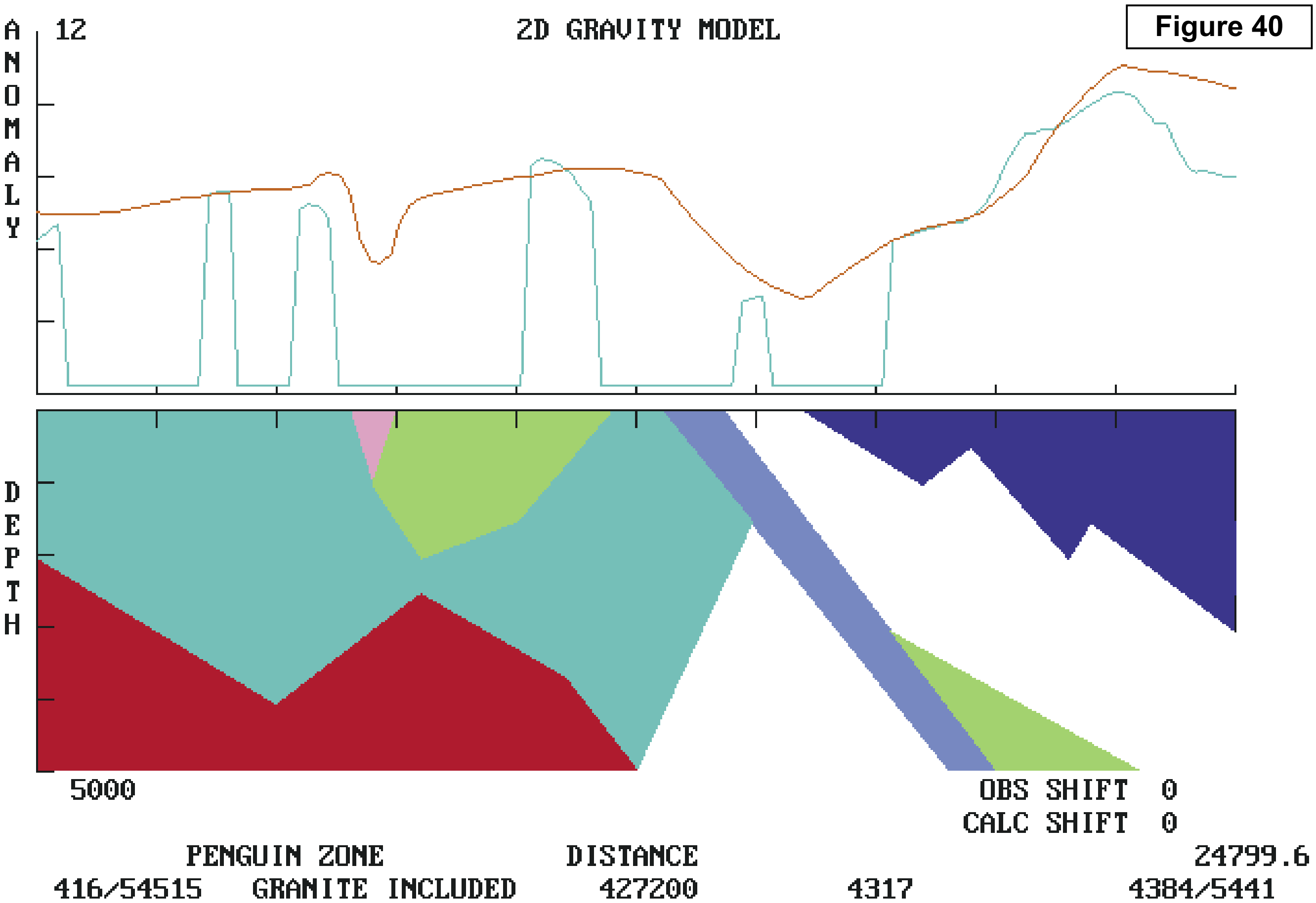


Figure 40
ANOMALY
12
2D GRAVITY MODEL
DEPTH
5000
OBS SHIFT 0
CALC SHIFT 0
PENGUIN ZONE
DISTANCE
24799.6
416/54515
GRANITE INCLUDED
427200
4317
4384/5441

Figure 41

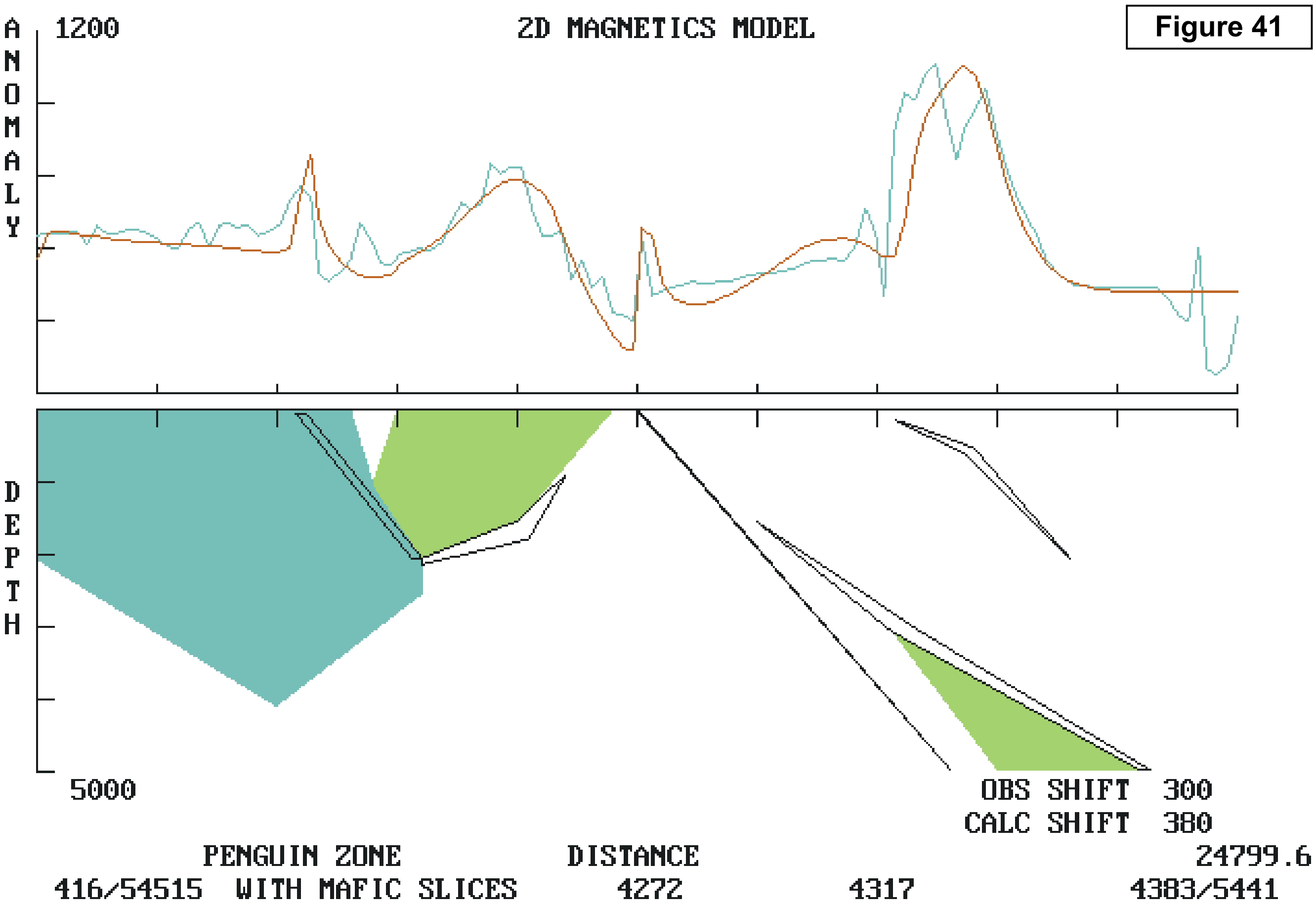
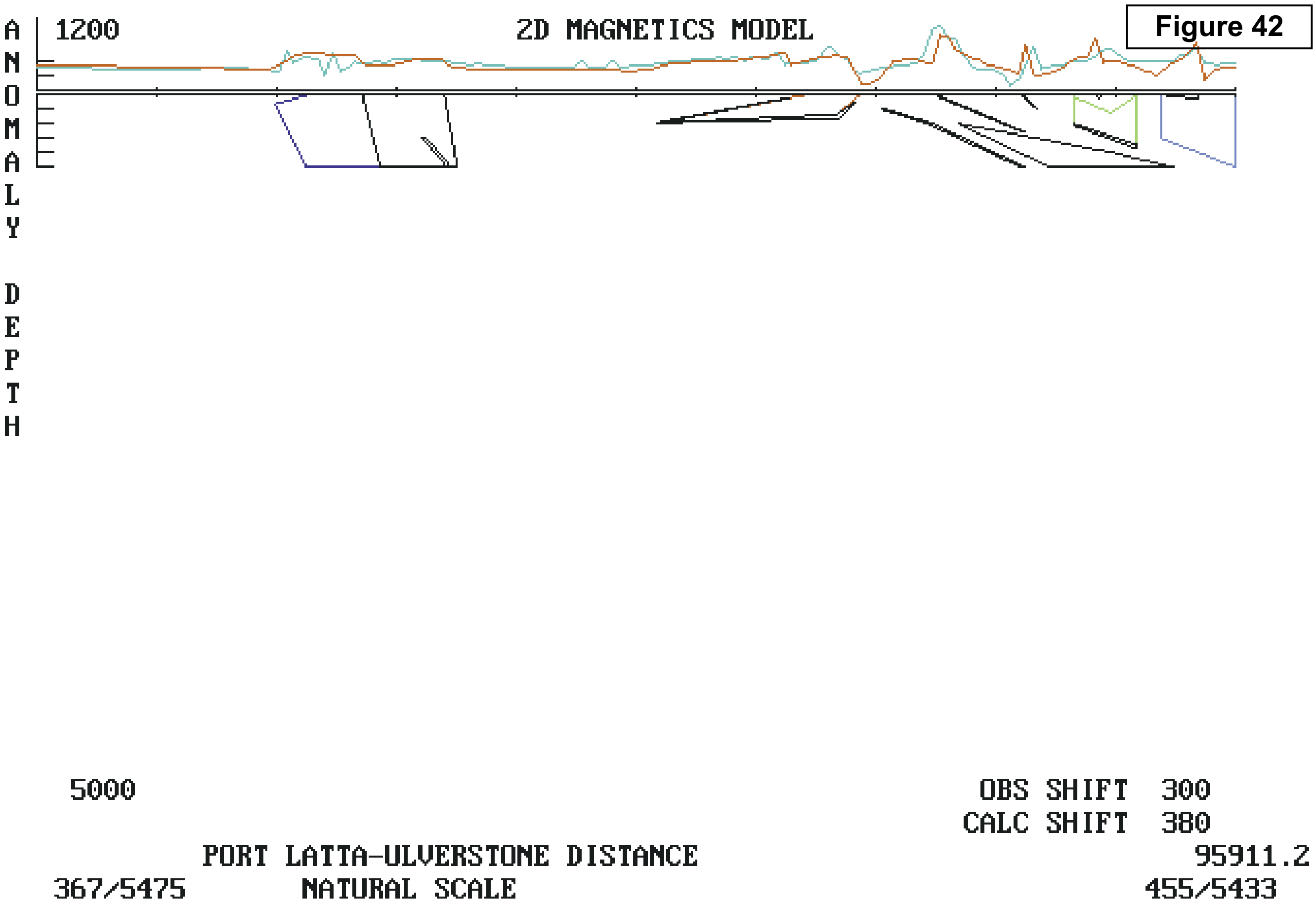


Figure 42



GOG RANGE

Recent mapping in the Gog Range area has enabled construction of sections suggesting possible relationships within Cambrian rocks. The map section published (McClenaghan *et al.*, 2001) was proposed for the test. Particular issues to be examined included whether the north face of the range is a basin-bounding fault which has been reversed, and whether the basin sequence is simple or disrupted. The distribution of some volcanic rocks, including an andesitic complex, may also be controlled by Cambrian structures. The modelling tests sought to review the range of possible structures, the proposed geological section, and the depth extent of implied faults.

The structure of the Gog Range was discussed by Woodward *et al*. (1993) who suggested that several Cambrian structures (folds and thrusts) were incorporated in the sequence and eroded by Late Cambrian uplifts.

Magnetic data in the Gog Range area are interesting, and clearly anomalous. The principal suggestion of discontinuities, not explained by surface mapping, can be found along the range itself. A substantial response is observed beneath the eastern half of the range but it is absent to the west — why? Where do the major faults trend? Inspection of the Gog map shows that a significant break crosses the range and this is reflected in distortion of the main fold. This break is highly acute to the proposed section. Do any of these fracture systems link with the andesitic complex?

These issues have been examined using the control of the geological mapping, the stratigraphic implications of the inferred section, and both gravity and magnetic data.

Gravity coverage is variable and relatively poor and the magnetic coverage varies in quality — mainly because of clearance deviations and general elevation. In order to control response variability due to terrain, both data sets were continued to a fixed level which equals the height of the range (700 m). All modelling has been undertaken against this reference.

Further, within the constraints of the project, five profiles have been examined in detail. This array approach was made necessary by the approximate coincidence of the map section and the change in magnetic character. Neither element or section could be considered representative. Thus the profile of the map section was modelled but as a foil to sections further east and west which reflected strike character. These three dip lines were then tied by two E–W strike lines, one of which was along the axis of the range and the other along the synclinal axis of the volcanic succession. No solution was accepted which could not be consistently tied between all five profiles. In each case the gravity data were used to constrain rock and unit volume estimates.

GOG 1 (446 700 mE, 5 400 000 mN – 5 411 000 mN)

This section samples a non magnetic expression of the range and volcanic rocks.

The gravity solution provides a satisfactory correlation in all zones (fig. 43) but the range crest and this may reflect data problems. There is a general balancing of Ordovician and Cambrian rocks to the south of the range but the estimates and proportions are valid. The zone south of the range is faulted but the data cannot resolve dips. The range cap is present either as a low angle structure or an unconformity. The andesitic complex cannot be widely distributed and this conclusion is consistent with mapping.

Magnetic analysis confirms the general implication about the distribution of andesites and the universal lack of magnetic contrasts within the volcanic succession (fig. 44). The only variations are related to lavas near the range crest but the responses are depth limited and near surface. Small variations cannot explain the broad features which can only be generated by deep-seated layers of intensely magnetised material which can be neither bulky, nor shallow. Modelling shows that thin slices (ultramafic rocks implied) are required near or at the base of the volcanic 'pile' beneath virtually every (perhaps all) block segment. These elements generate the predominant negative residual field and their depth leads to an absence of high amplitude positive responses. Note that the intense contrasts associated with ultramafic rocks can be arranged either in addition or opposition to the modern field vector and detailed observations have shown that the contrasts may vary rapidly, and locally, in sign.

GOG 4 (452 700 mE, 5 400 000 mN – 5 411 000 mN)

This profile approximates the position of the section printed on the 1:25 000 scale Gog geological map (McClenaghan *et al*., 2001).

The gravity model (fig. 45) supports the syncline concept and an overlapped Ordovician range capping. This surface dips shallowly across the fold, either as a thrust or unconformity. The northern end of the line indicates an unconformity as the general solution. The sequence is quite thin beneath the fold axis and this implies some low angle faulting with displacement from the north. The andesitic complex is restricted to the northern block.

The magnetic model (fig. 46) is very instructive in that it supports the ultramafic basal implication of GOG 1 but with the suggestion of two shallow penetrations; one into the range core and another along the andesitic margin.

GOG 6 (456 700 mE, 5 400 000 mN – 5 411 000 mN)

This profile samples the entire range and the belt of large magnetic anomalies.

The gravity model (fig. 47) suggests a much thicker volcanic pile with a shallow core of sedimentary rocks. The Ordovician range cap may be interpreted as a thrust or unconformity but it is clearly very shallow. The fold relationships do indicate an erosional surface.

Andesites are not fully resolved but may wrap around the entire fold. Were this to be the case then the section in the centre of the model should be shallowed by at least 1000–1500 metres.

The magnetic solution (fig. 48) does not require this and the underlying ultramafic rocks fit best at the depths implied gravimetrically. This data also implies boundary definition of the andesites by the Cambrian mafic rocks, two of which reach close to surface. These, and a thicker pod at nearly five kilometres depth beneath the range, generate the large magnetic responses observed.

GOG E1 (Test tie, 445 000 mE – 460 000 mE, 5 403 550 mN)

The gravity and magnetic models (fig. 49, 50) based on the dip lines easily fit the data.

GOG E2 (Test tie, 445 000 mE – 460 000 mE, 5 407 600 mN)

Both gravity and magnetic models (fig. 51, 52) derived from the dip line models fit the data comfortably and both stress the abnormal character of the magnetic field as well as the nature of the andesitic pile — for that is clearly what it is. The pile is spatially restricted but has clearly been subject to marginal dislocation. Mafic rocks form only a basal veneer in this section.

The magnetic field pattern observed is quite unusual and abnormally and consistently low intensity. An unusual combination of high contrast sources at depth is the only solution for such a pattern and the dip lines have signalled how it should be assembled.

SUMMARY

The varied magnetic character of the region reflects the presence and distribution of thin (100–400 m) slices of ultramafic rocks (high contrast sources) at depths of typically 2000–5000 m, with rare extensions to shallower depth. This material forms magnetic basement and the volcanic piles, andesites and volcano-sedimentary sequenes overlie it. The placement of this magnetic basement may be originally structural, for it is unlikely to have been a later structural emplacement. Note that magnetic material forms such a basal layer in many areas and this implies its existence prior to deposition of mid Cambrian rocks. The mafic material has been dislocated subsequently as shown by the many protrusions into faults and thrusts which disturb the Cambrian (and other rocks). Mafic material in this situation allows mapping of subsequent offsets and deformations, and many slices are now very low angle and commonly dip to the north or northeast. Some other structures cut the sequence or bound some units, especially the andesitic complex, but these dip mainly to the southwest, and much more steeply.

The results show that there is no basin-bounding fault along the range but there may be a low angle thrust or unconformity which post-dates deformation of the volcanic rocks. An unconformity seems the most likely situation given the distribution of all materials. The andesitic complex is present as a pile but many elements of it, perhaps all, are now fault-bounded.

Addendum

After this interpretation was presented in draft form staff from Mineral Resources Tasmania inspected core, from the Lower Beulah region, which contains barites mineralisation and which lies near or within the northern andesite body.

Hole DD84 BB4 (collar at 450 590 mE, 5 408 478 mN, drilled to 010° initially at dip of -50° to final depth of 219 m) passed from greywacke through a transition zone into predominantly andesitic lavas. The contact appears conformable and gradational with localised barite veining, although sequence facing is equivocal and inconsistent.

Hole BB6 (collar at 450 780 mE, 5 408 647 mN, subvertical, drifted to 225° and depth of 400 m) was drilled almost entirely in the andesitic sequence but minor sedimentary horizons were observed. There are also several high strain zones and a significant fault zone at 117 m, with a steep southerly dip and south-side down sense of shear. Other zones are associated with veinlet barite-sulphide mineralisation.

These two holes confirm what was suspected from surface mapping and this new interpretation. Firstly, the situation is extremely variable, even locally (the holes are very close), and this is implied in the magnetic interpretations. Some boundaries are clearly gradational, others fault bounded.

Secondly, the established fault zone in BB6 is consistent with the model for line GOG4 (fig. 45, 46). The model set indicates a mix of dislocation and conformity but cannot constrain the age of movement or fluid flow.

It is, therefore, likely that parts of the contact between andesites and other Cambrian rocks is conformable whilst other parts have been dislocated. A first order indication of both the scale of such dislocation, and its distribution, is provided by this new interpretation.

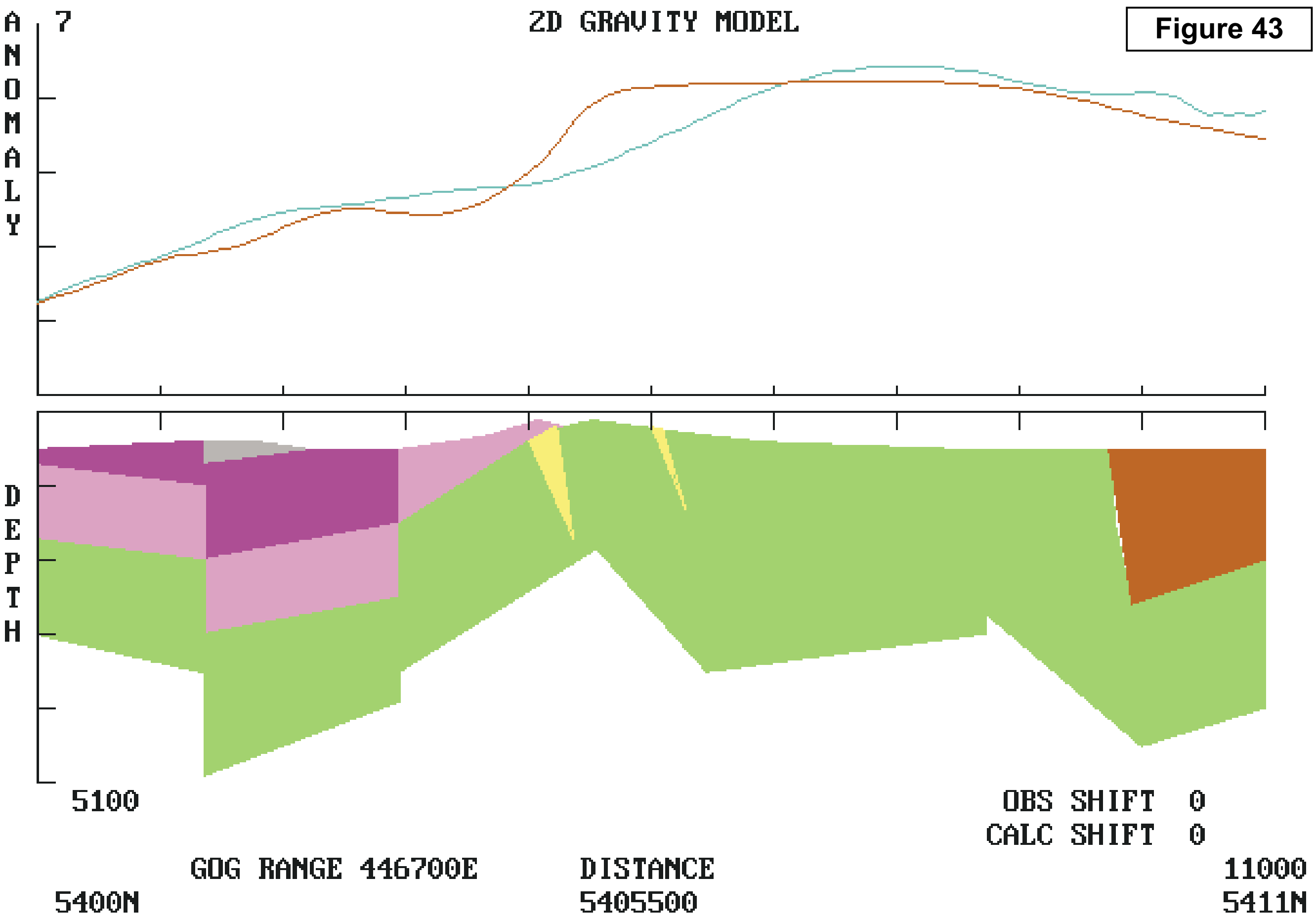


Figure 43

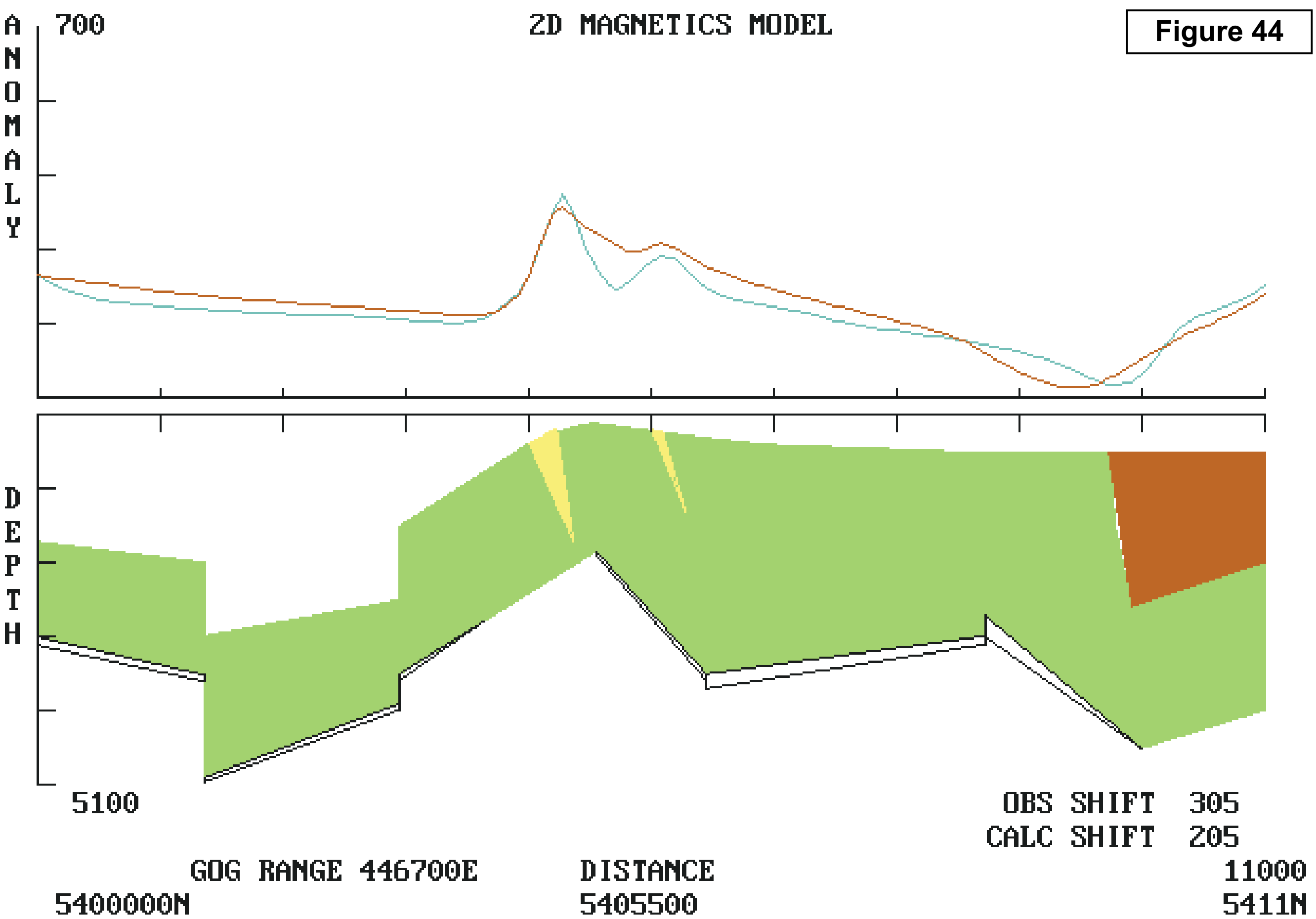


Figure 44

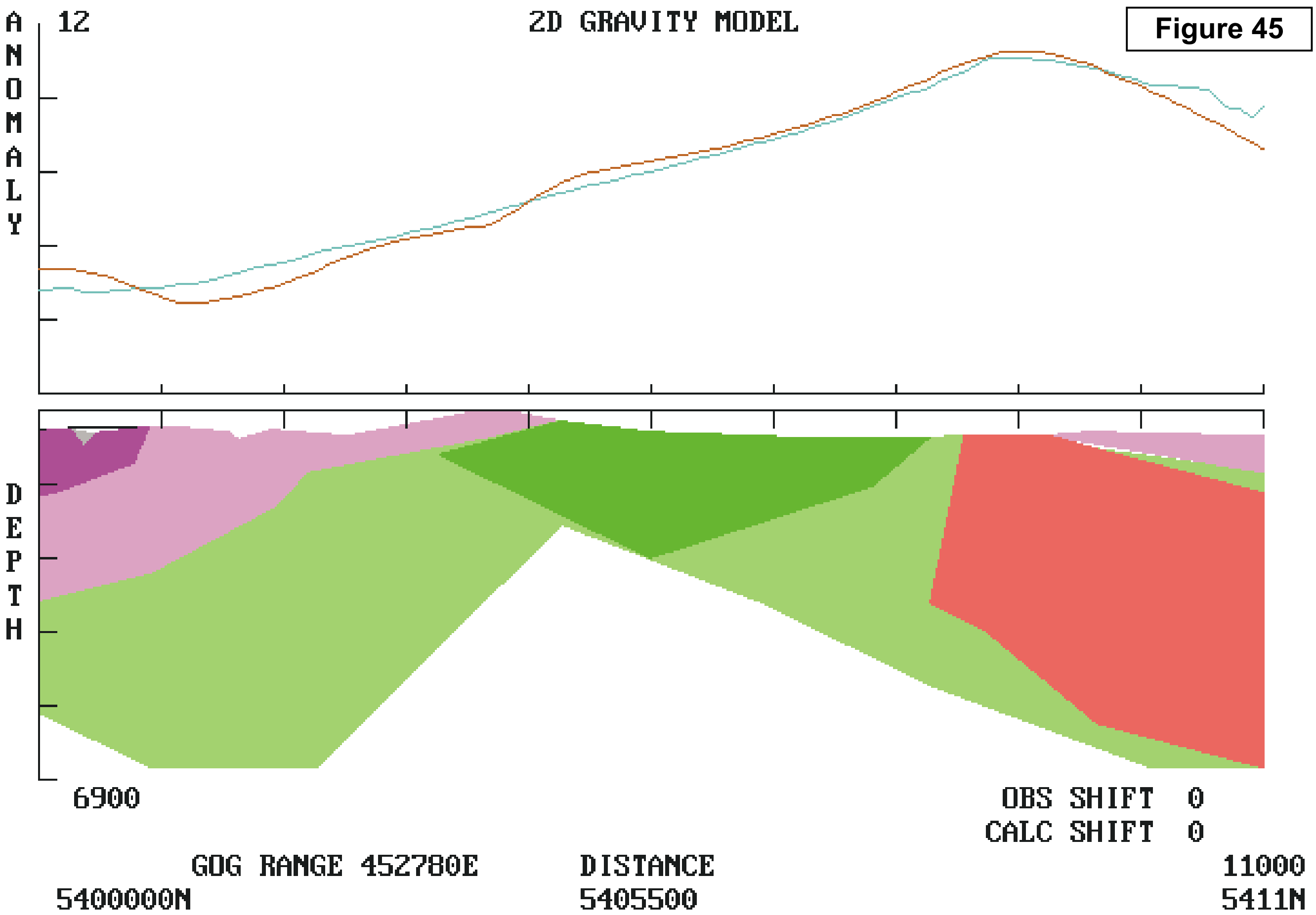


Figure 45

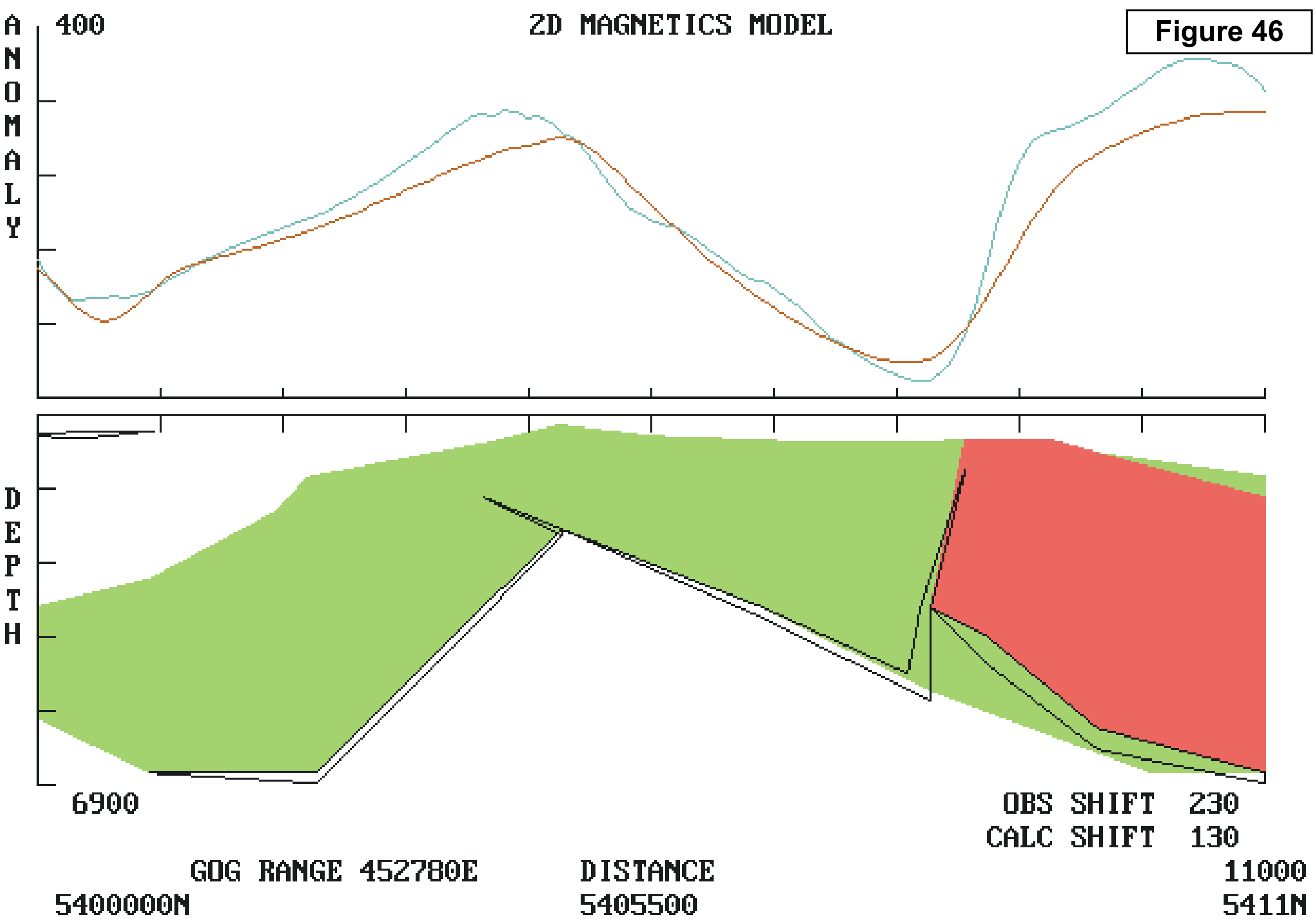


Figure 46

Figure 47

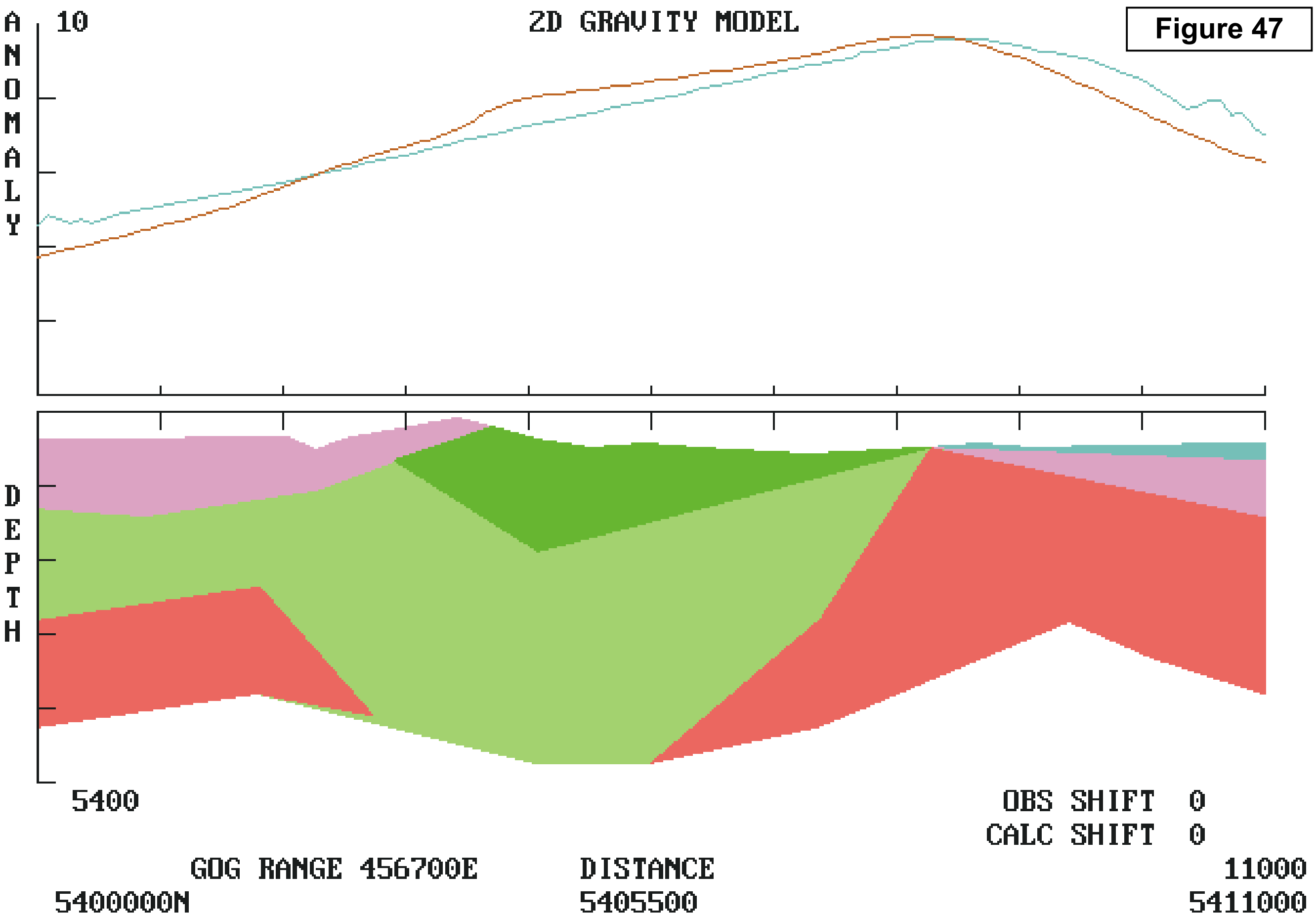
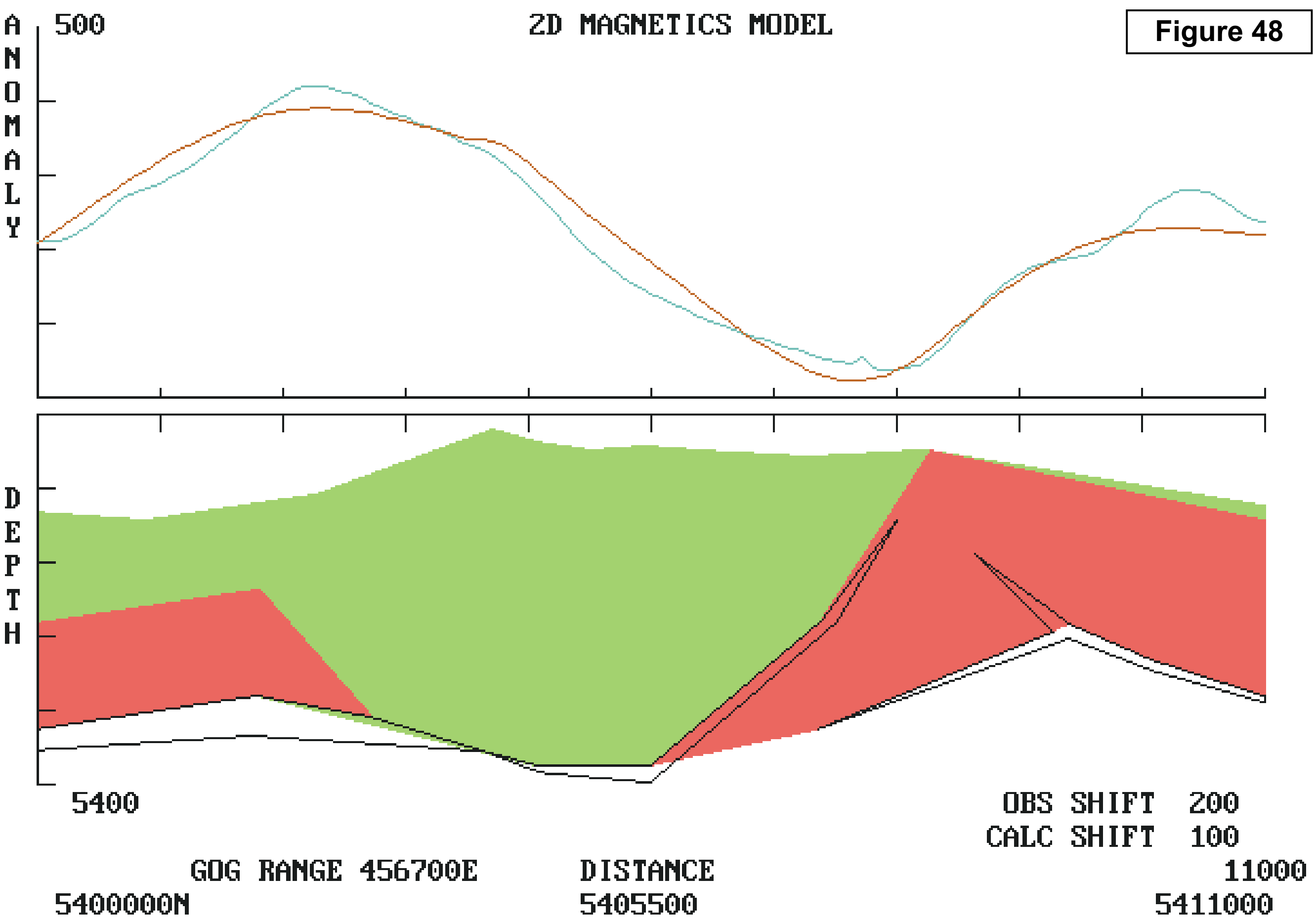


Figure 48



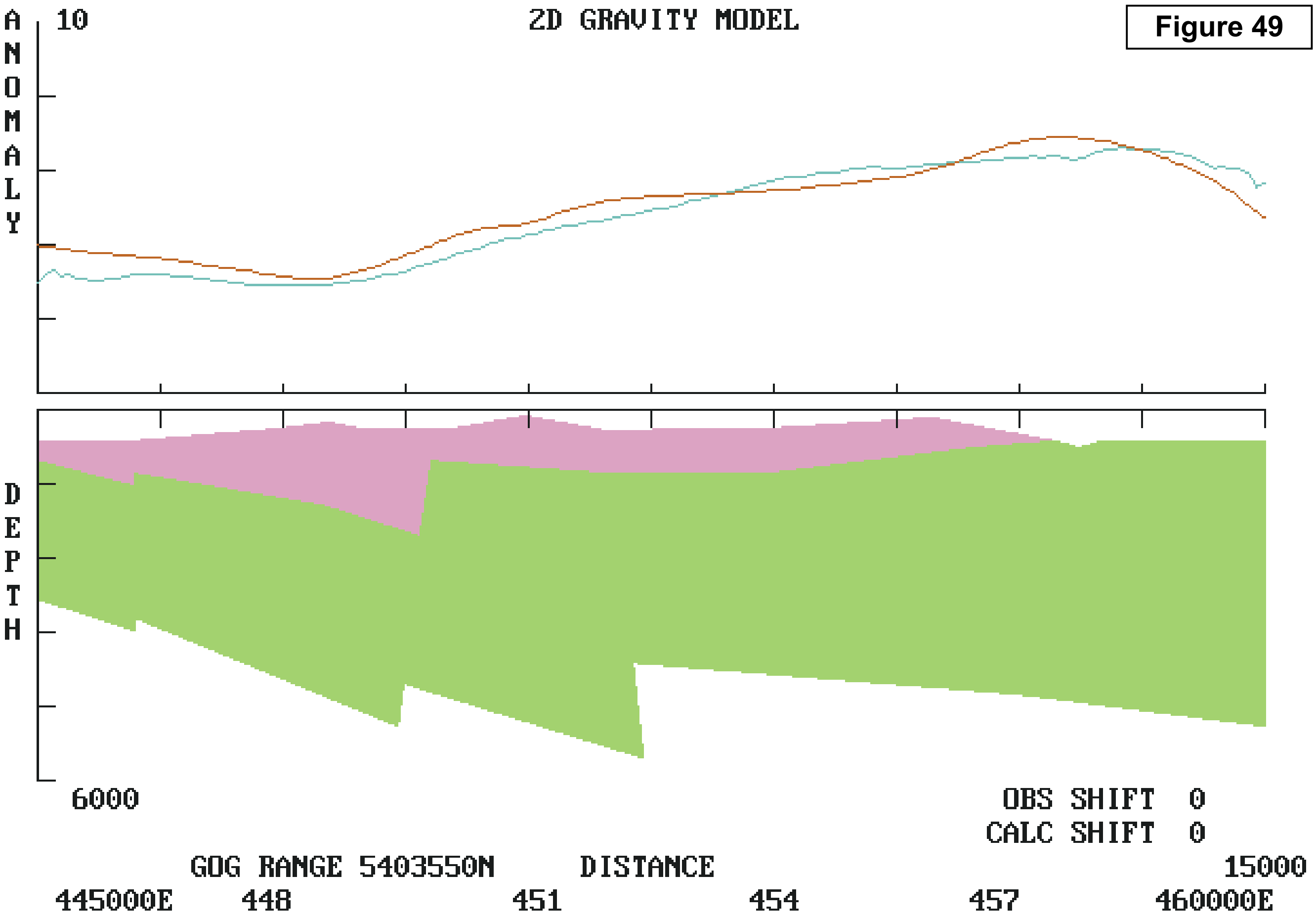


Figure 49

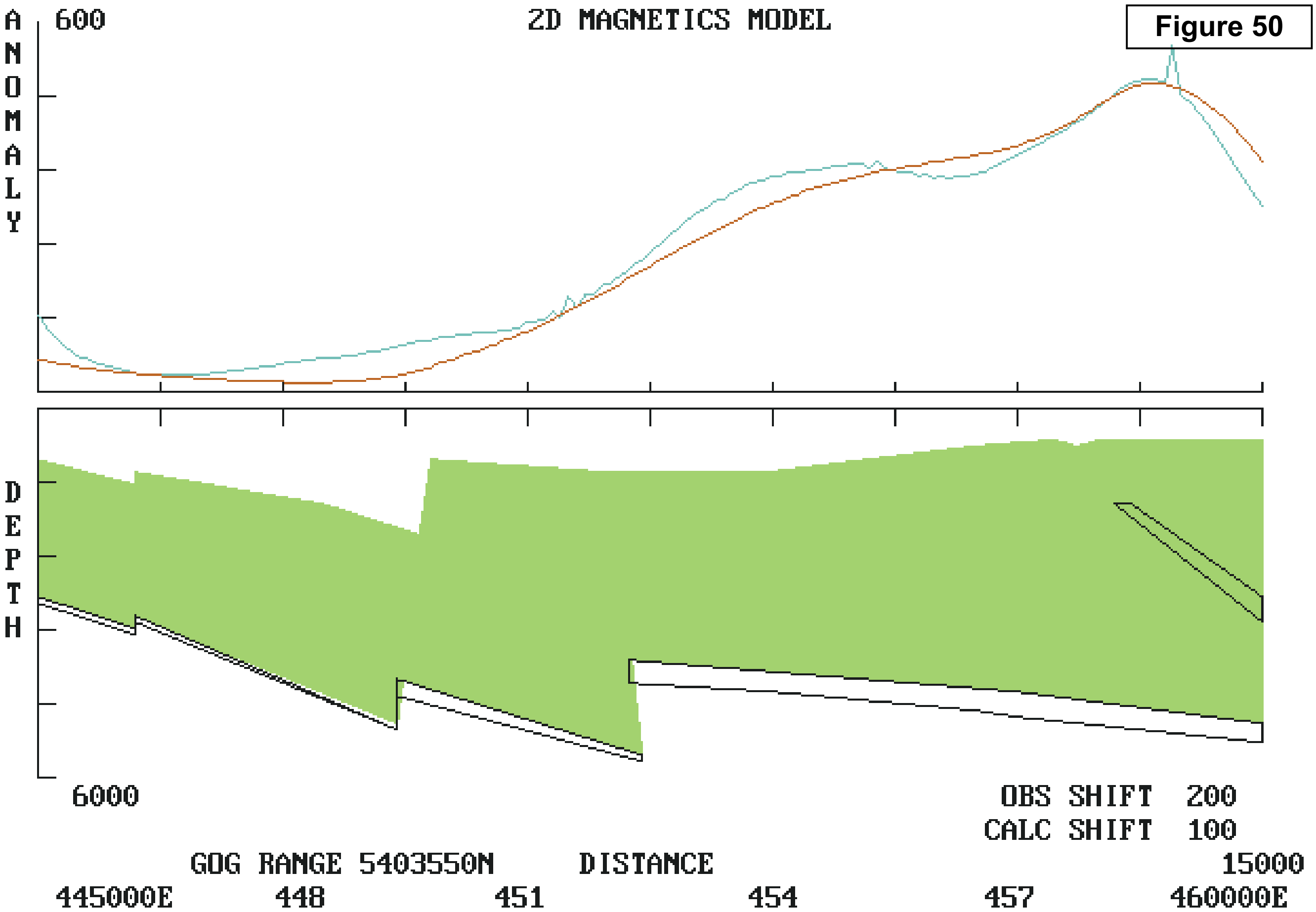


Figure 50

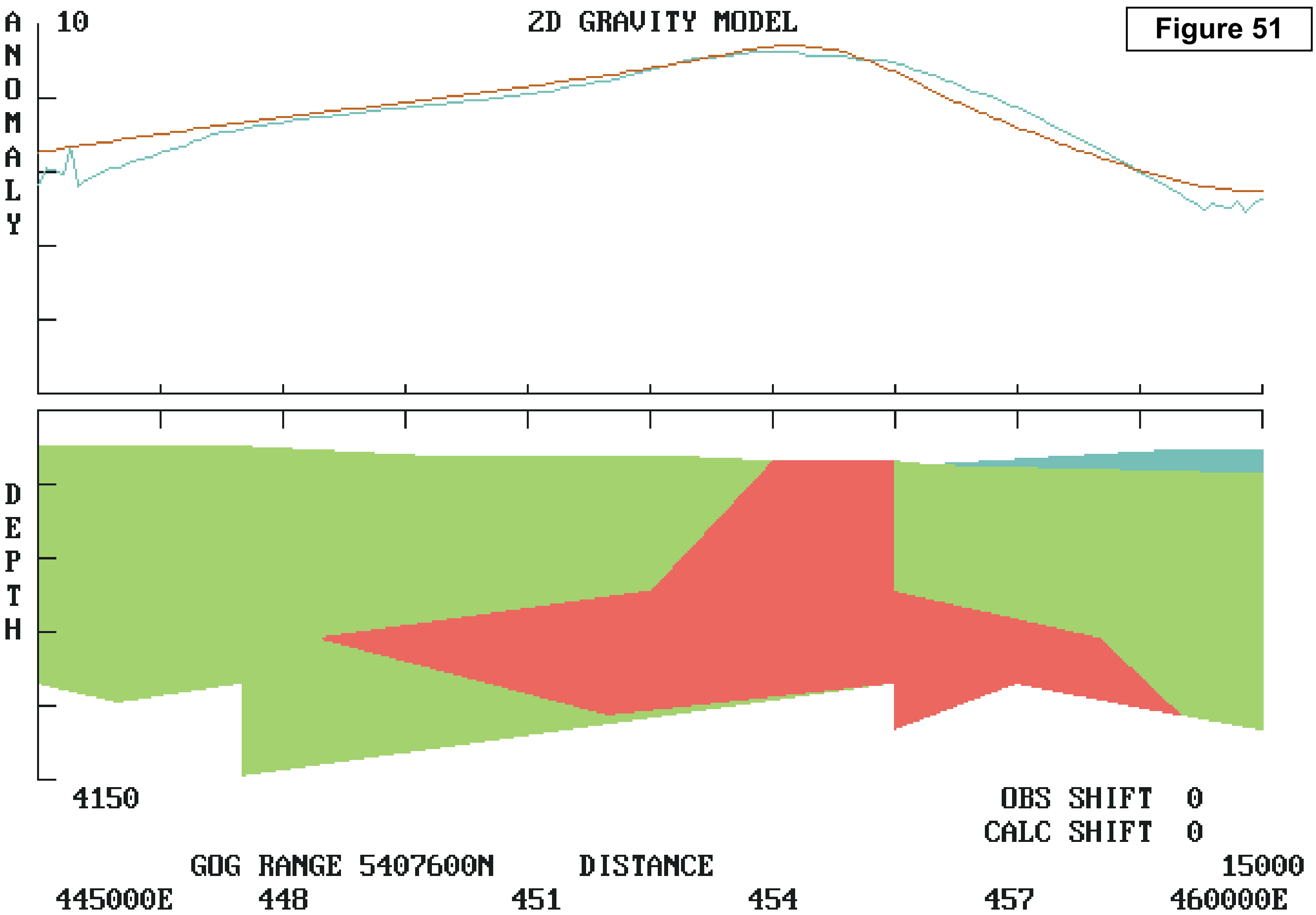


Figure 51
2D GRAVITY MODEL
ANOMALY
10
DEPTH
4150
OBS SHIFT 0
CALC SHIFT 0
GOG RANGE 5407600N DISTANCE
15000
445000E 448 451 454 457 460000E

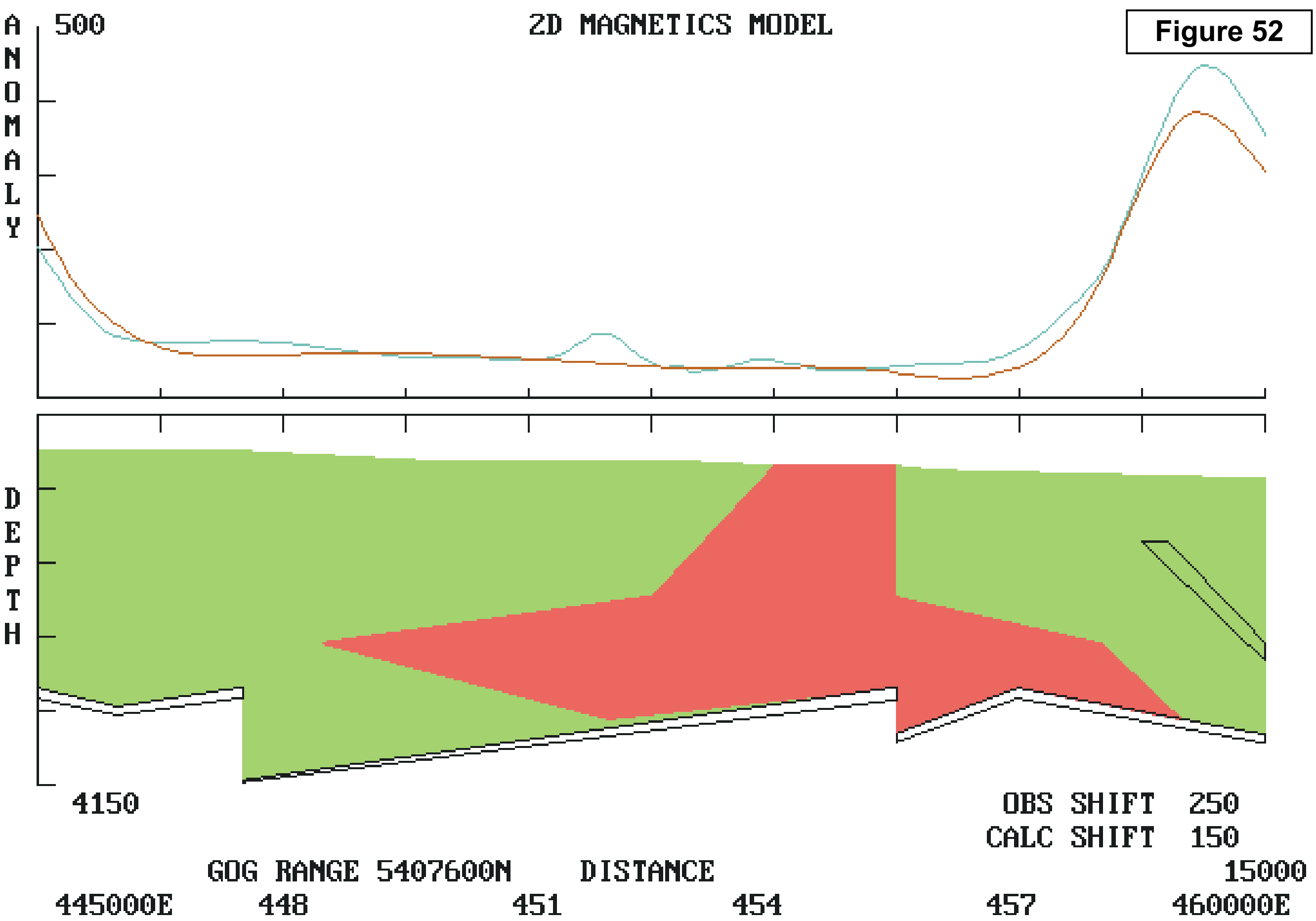


Figure 52
2D MAGNETICS MODEL
ANOMALY
500
DEPTH
4150
OBS SHIFT 250
CALC SHIFT 150
GOG RANGE 5407600N DISTANCE
15000
445000E 448 451 454 457 460000E

BADGER HEAD

This nearly E–W transect crosses the proposed boundary between east and west Tasmania. It includes structures emergent at, or near, surface which are believed to be first-order fluid pathways for gold mineralisation throughout eastern Tasmania and is near the Tasmania Reef at Beaconsfield. The geology is complex and controversial. An aim of this analysis was to suggest the character and depth of the Proterozoic rocks near Badger Head.

Two levels of analysis were completed; a relatively detailed appraisal between Port Sorell and the River Tamar (455 000 mE/5 434 000 mN – 495 000 mE/ 5 436 000 mN) and a more regional view (424 000 mE/ 5 433 500 mN–505 000 mE/5 437 000 mn).

The original concept of displacement of the Badger Head block was derived from gravity data (Leaman *et al*., 1973) and refined by Leaman (1992). The detailed models examined in this study were derived from sections drawn on recent 1:25 000 scale maps of the north Tamar region. Both gravity and magnetic data (fig. 53, 54) indicate that a suite of east-dipping structures, with a limited involvement of ultramafic rocks, extends towards the Tamar from the east side of the Badger Head allochthon and that another wedge of materials underlies it from the Port Sorell area. This lower wedge extends almost as far east as the eastern side of the block and completely underlies it. All structures dip very shallowly, as shown in Leaman (1992) and Figure 57. Pull-apart structures are almost certainly present and have affected development and structuring in post-Permian rocks (also Leaman, 1992). The detailed models suggest a depth limitation to the fundamental detachments and a possible pattern to motion.

The regional extension of this analysis (fig. 55, 56) confirms the detailed pattern but inserts it within an extended setting. Rocks east of the River Tamar are also structurally bounded, depth limited at about 4 km within the section, and intruded by granite (presumed Devonian in age). Several slices of basement composition are also involved between Beaconsfield and the eastern limit of the model.

It should be noted that the Badger Head Block has neutral or core Tyennan/Rocky Cape Block properties and that the slices of basement east of it, and beneath the entire northwestern extension of the section, have similar properties. None of the included blocks have properties consistent with the Burnie–Oonah Formation, Arthur Lineament or Forth complex.

This east-dipping slice pattern extends west of Port Sorell to the west end of the line with a form which was predicted by Woodward *et al*. (1993). The gravity model (fig. 55) constrains volumes and provides a solution which suggests a simple soling detachment with splinters, and which extends at least 80 km from, or east of, the River Tamar. The magnetic data support this view but indicate that the western segments (west of Latrobe) include ultramafic slices which tend to confirm the nature of the detachment. One of these detachments splits and enters the Forth Block as an additional structural boundary. The model also suggests that the Forth Block is depth limited, quite distinct, and unrelated to the general run of basement.

The general style has been considered further in the *Dial Range* section.

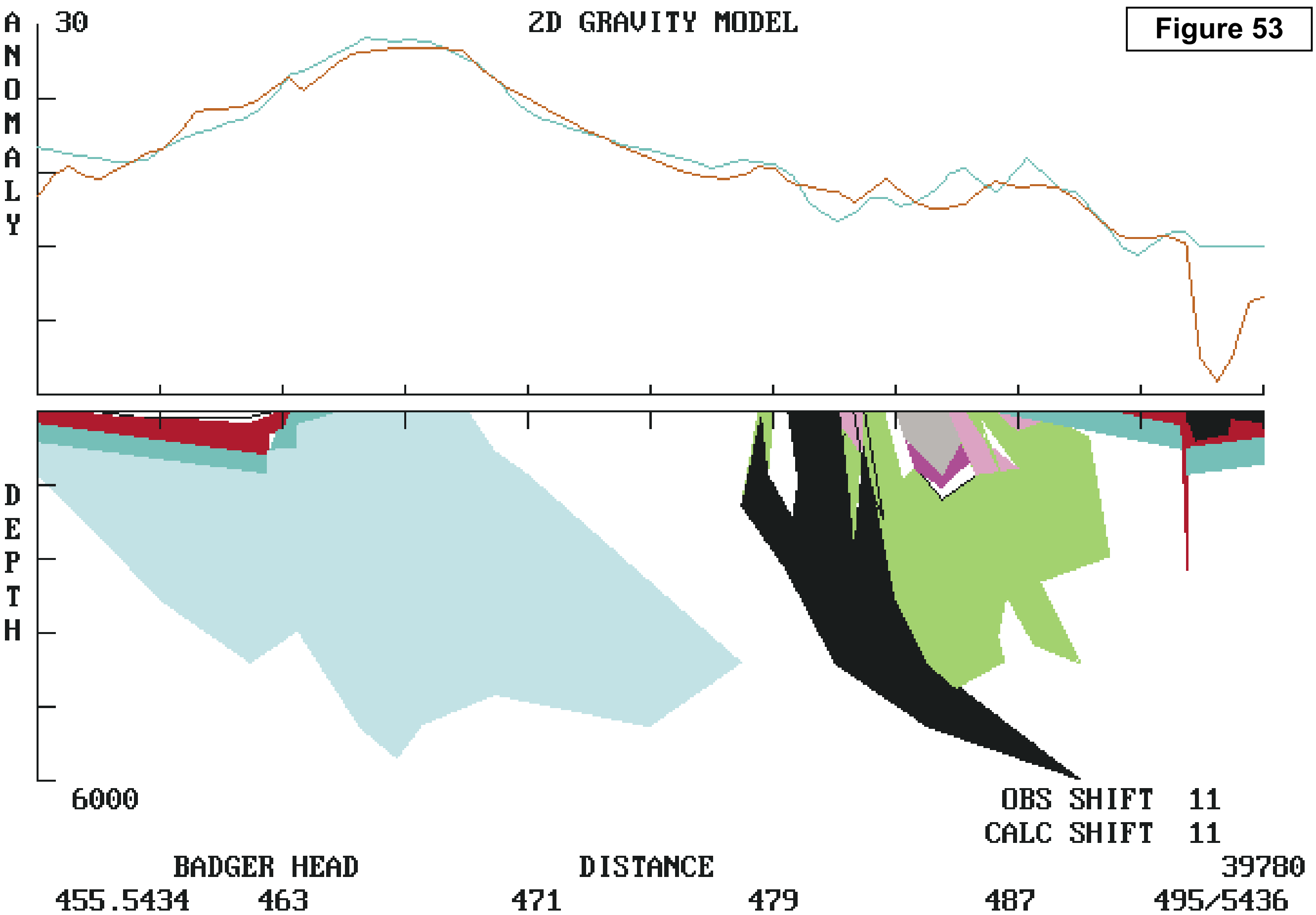


Figure 53

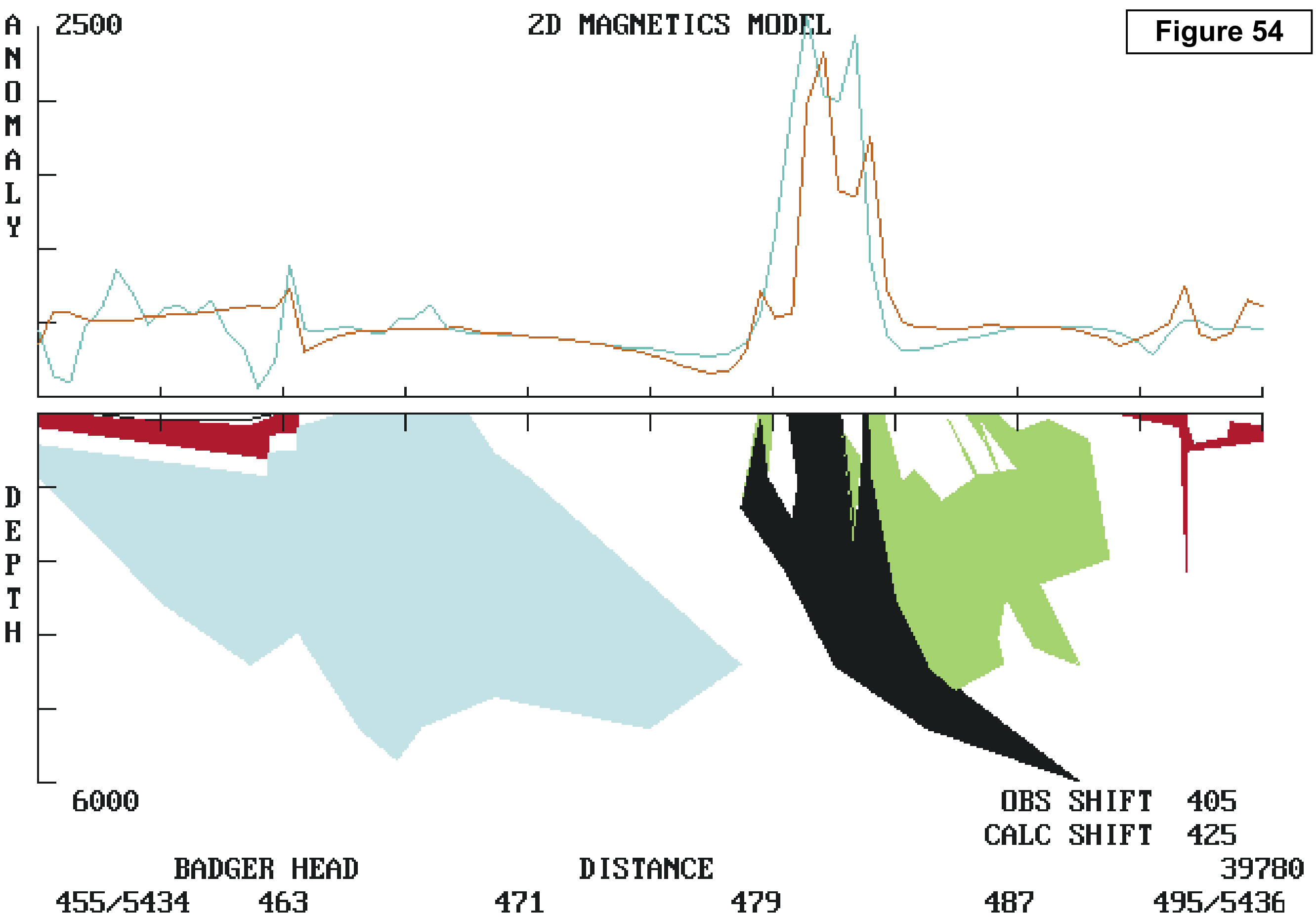


Figure 54

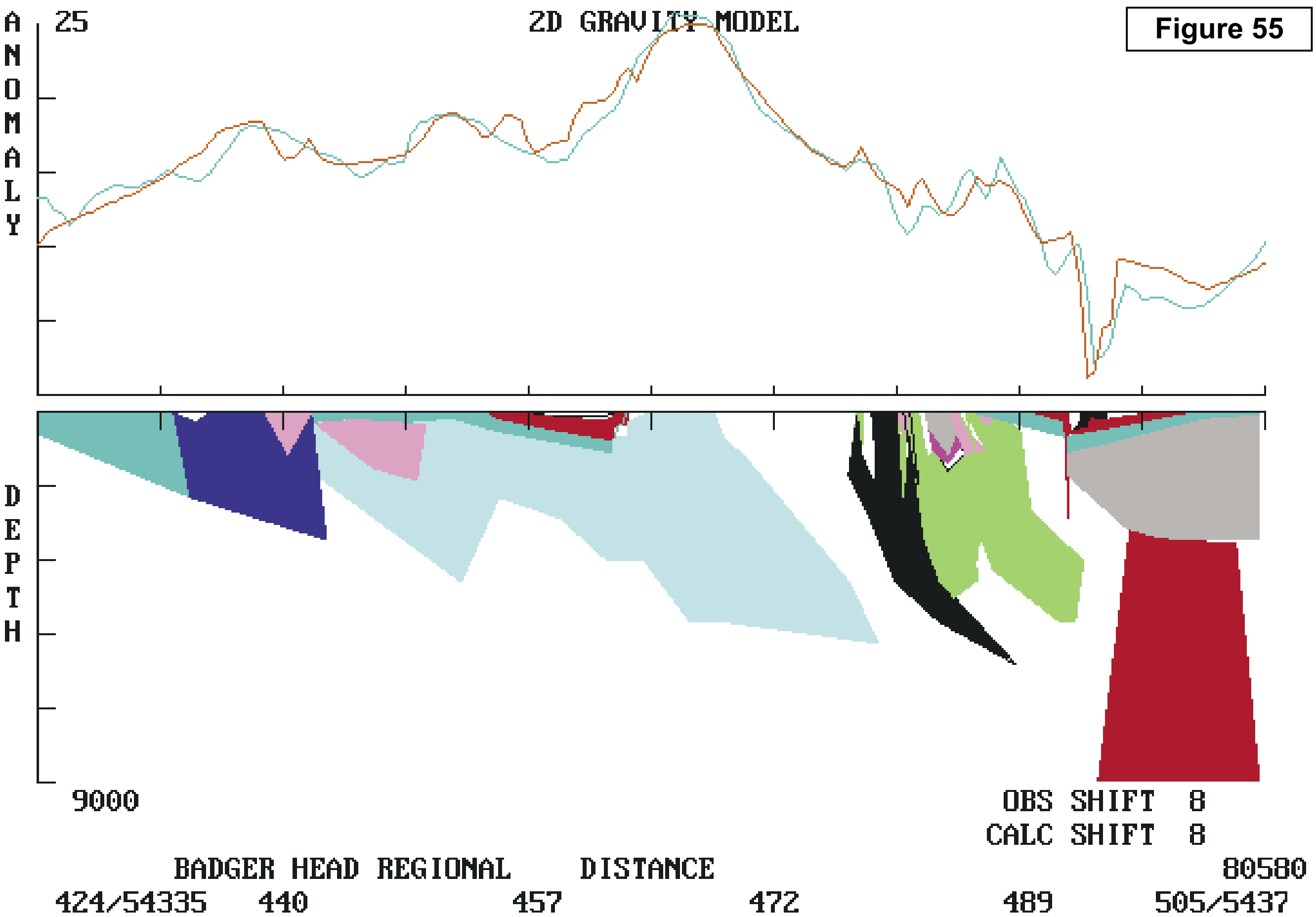


Figure 55
2D GRAVITY MODEL
ANOMALY
25
DEPTH
9000
OBS SHIFT 8
CALC SHIFT 8
BADGER HEAD REGIONAL DISTANCE
80580
424/54335 440 457 472 489 505/5437

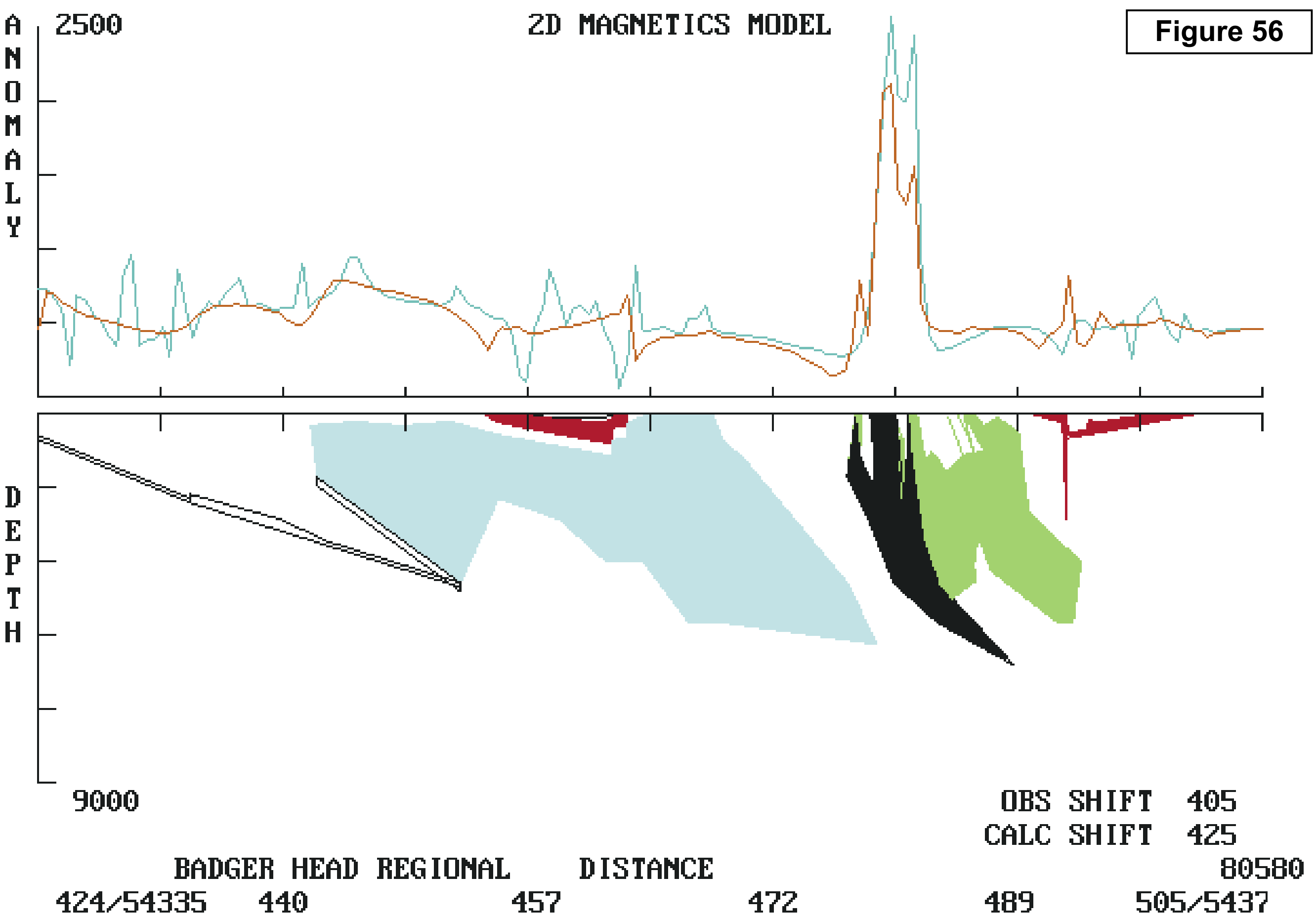
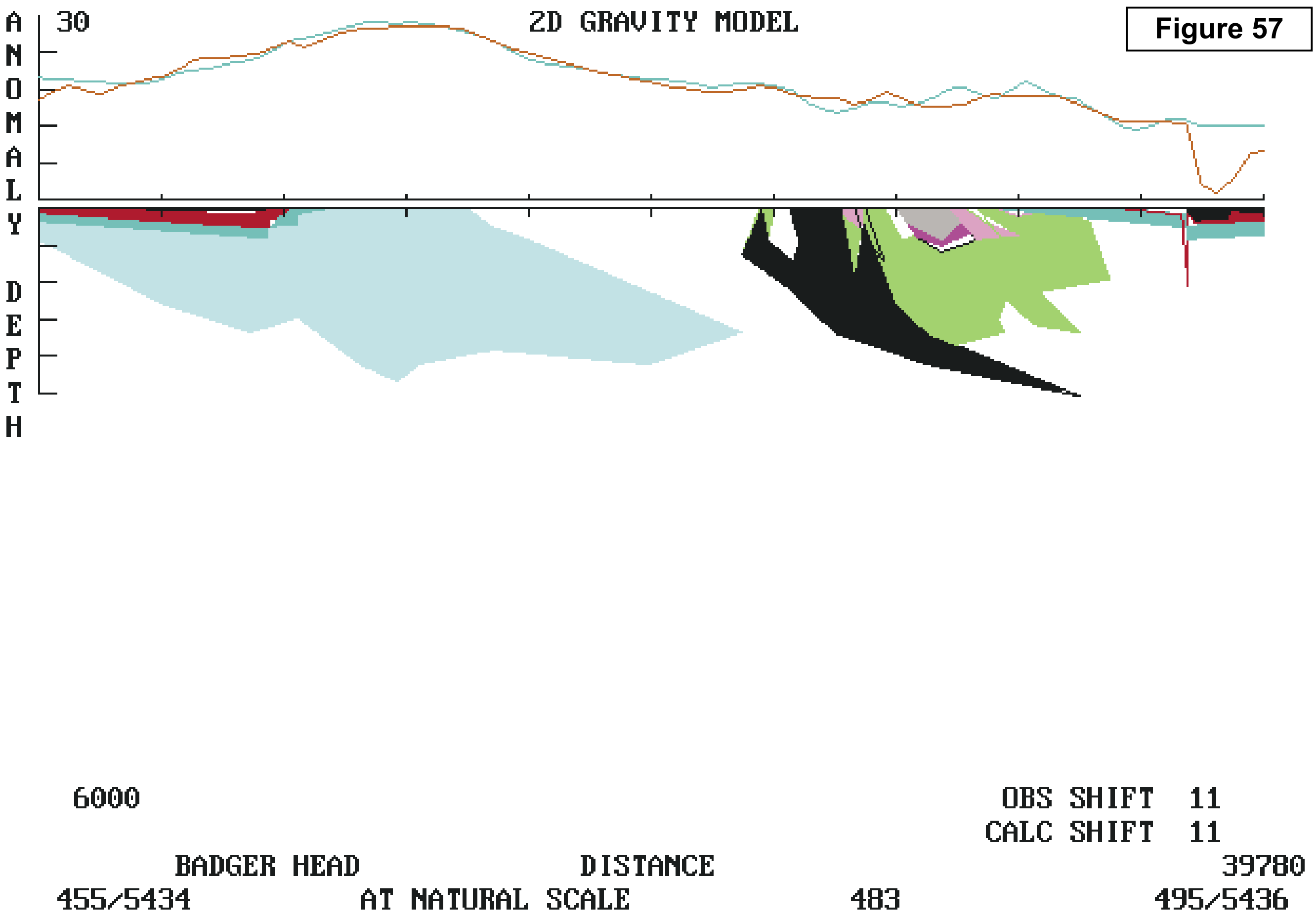


Figure 56
2D MAGNETICS MODEL
ANOMALY
2500
DEPTH
9000
OBS SHIFT 405
CALC SHIFT 425
BADGER HEAD REGIONAL DISTANCE
80580
424/54335 440 457 472 489 505/5437

Figure 57



2D GRAVITY MODEL
30
ANOMALY
DEPTH
6000
OBS SHIFT 11
CALC SHIFT 11
BADGER HEAD
DISTANCE
39780
455/5434
AT NATURAL SCALE
483
495/5436

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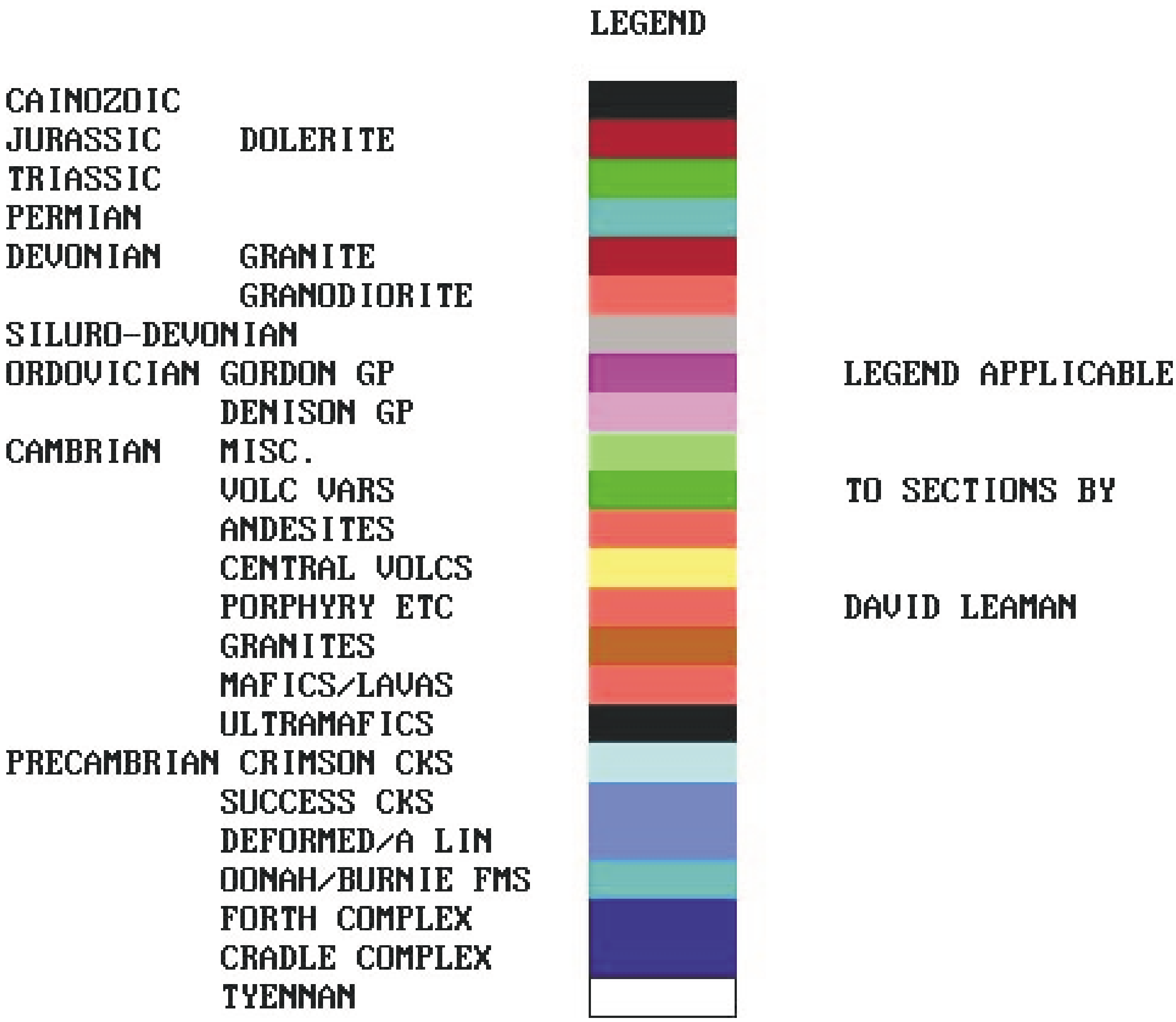
[30 May 2002]

APPENDIX 1

Table of rock properties

Density is expressed as contrast with background and reduction density of 2.67 t/m^3.

Age and unit		*Density* t/m^3	*Susceptibility* *cgs*	*SI*
Quaternary	-1.2	0		
Tertiary	sediments	-0.7	0	
	basalt	0.23	>0.001	>0.01
Jurassic dolerite		0.23	>0.004	>0.05
Triassic		-0.22	0	
Permian		-0.13	0	
Siluro-Devonian		-0.1	0	
Devonian	granite	-0.05–0.07	0	
	granodiorite	0.03	~0.0002	~0.0025
Ordovician	Gordon Group	0.07	0	
	Denison Group	-0.07	0	
Cambrian	Tyndall/Yolande groups	0.05–0.07	0.0002	0.0025
	Dundas Group style	0.05–0.07	<0.0002	<0.0025
	sundry variations	var	var	
	andesites	0.1–0.15	>0.0002	>0.0025
	central volcanics	0.06–0.08	~0.0002	~0.0025
	porphyry	-0.03<0.05	<0.0002	<0.0025
	granite	-0.05/0.02	>0.0005	>0.006
	ultramafic	var	>0.01	>0.12
	Que style basalts	0.1–0.2	>0.0003	>0.0035
	(note many Cambrian units exhibit variations in properties locally when altered)			
Precambrian/Eocambrian				
	Crimson Creek Formation	>0.1	>0.001	>0.01
	Success Creek Formation	>0.07	0	
	Lineament rocks	>0.1	>0.0002	>0.0025
	Oonah/Burnie Formation	0.08	<0.0005	<0.006
	Forth Complex	0.1	0 var	
	Tyennan/Badger/Rocky Cape	0	0	
	Cradle Block var	0.1	0	
	sundries/amphibolites	0.15	0.0003	0.0035



Colour coded legends for all models

APPENDIX 2

Details of models presented

These data are available on CD-ROM as text files and scanned images.

- Co-ordinates for all Leaman models are referred to the origin.
- Horizontal distance is x axis.
- Header properties include name of formation, density and magnetic contrasts.

Mineral Resources Tasmania
Tasmanian Geological Survey
Record 2002/15

Quantitative interpretation of magnetic and gravity data for the Western Tasmanian Regional Minerals Program

Part 2:

S. S. Webster

In this section, written by Steve Webster, aeromagnetic and radiometric data have been used in conjunction with existing geological data to qualitatively confirm or improve the geological understanding of the study areas before modelling. Magnetic modelling, with gravity modelling where the data are sufficiently close spaced, has been used to guide the scaling of rock packages and place general limits on volumes and relationships.

An additional area was added to the initial study to examine the southern margin of the Heemskirk Granite and the geology of the area near the Avebury nickel deposit. Higher resolution aeromagnetic data (50 m spaced N–S traverses) over the region were made available for modelling by Allegiance Mining NL, holder of the tenement over the area. The data from this high resolution survey will become open file in May 2003.

Heazlewood–Arthur Lineament

The Arthur Lineament trends NNE–SSW across northwest Tasmania and separates the Rocky Cape Element, on the west, from the Dundas Element and the Sheffield Element, to the east. The Precambrian rocks of the Arthur Lineament consist in part of equivalents of the Rocky Cape Group and the Oonah Formation (Seymour and Calver, 1995) that were metamorphosed in the Cambrian. The assemblage of metamorphic rocks making up the Arthur Lineament is the Arthur Metamorphic Complex.

The lineament is expressed in the geophysical data as an almost coincident gravity high and magnetic high complex some 100 km long and 25–50 km wide. The gravity anomaly is broad with shallow flanks and is only broken by the low zones caused by the Meredith and Heemskirk granites. The magnetic expression of the Arthur Lineament is characterised by a series of strong narrow anomaly trends running parallel along the feature, with necking of the zone in the vicinity of the Savage River iron ore deposit. The lineament is comprised of major thrust slices that juxtapose the geological units, and several major splay faults cut across the geology at shallow angles with significant offset of magnetic anomalies.

A traverse, of gravity and magnetic data, has been interpolated in an attempt to model the features of the Arthur Lineament, the Heazlewood River Ultramafic Complex (HRUC) units at Cleveland, and the tongue of Meredith Granite that extends to the north of the main intrusion. This traverse extends from 340 000 mE, 5 420 000 mN to 380 000 mE, 5 400 000 mN as shown in the geology map (fig. 59) and TMI image (fig. 60).

The gravity and magnetic data in the profile (fig. 61) are responding to different aspects of the geology, although joint modelling of the data sets has identified some of the major geological features. The shallow outcropping units of high magnetic susceptibility, such as amphibolites, ultramafic rocks and the metamorphic units around the Meredith Granite, mainly influence the magnetic data. The gravity data, probably due to the station spacing poorly sampling the shallow units, are more influenced by deeper geological changes.

The dominant pattern in the magnetic data is the series of strong anomalies related to the Heazlewood River Ultramafic Complex that range up to 3200 nT. The HRUC is difficult to model as part of a 2D profile as it is composed of units with short strike length and varying orientation. The magnetic modelling also indicates that the units (k = 0.155 SI) have limited depth extent (<1000 m), shown by the width of the anomalies and the steepness of the flanks. A detailed 3D modelling exercise would be required to better define the distribution of the individual units in the HRUC. The modelling of the gravity high (30 mgal) shows that the ultramafic complex is located on top of a major basement high (schematic interpretation in Figure 62, with H:V exaggeration = 2:1) that is characterised by high density (~2.80–2.86 t/m^3) and low susceptibility. This basement high, of unknown composition but probably non-magnetic Precambrian rocks, is bounded on the west by a low angle thrust and by a steep fault on the east.

The western flank of the gravity high is located over the units of the Arthur Lineament that do not obviously affect the gravity data but have significant magnetic response. The magnetic anomalies (300–400 nT) are dwarfed by the HRUC anomalies, although some individual characters can be isolated by the modelling. The Pieman Fault (at 347 500 mE) is reflected by a local magnetic low that indicates a dip to the east of the contact between the Rocky Cape Group and the Timbs Group(?) units. The magnetic units of the Arthur Metamorphic Complex have limited depth extent (1000–1500 m) and variable dip; it is not possible to resolve the nature of faults within the complex without more detailed modelling than is possible in this regional study.

The narrow tongue of Meredith Granite, in the east of the profile, is characterised by a significant gravity and magnetic low. The gravity low has been modelled assuming the granite extends to a depth of seven kilometres, in agreement with other modelling (Leaman and Richardson, 1989), however the density required for the modelling is 2.58 t/m^3. This value is lower than normally used for the Meredith Granite and it may be that this phase has different physical properties, as is evident in the radiometric data. Significant magnetic anomalies (>1000 nT) are observed on either flank of the granite and are interpreted to reflect increased magnetic properties due to the thermal metamorphic effects of the granite. The interpretation of these anomalies indicates a dip away from the centre in accordance with the granite widening at depth.

There is no information in the regional traverse to define the nature of the 'Cleveland–Waratah Association'. The Whyte River Complex (at 366 000 mE) produces a reasonably strong anomaly (600–800 nT) that is modelled to be due to a broad block of moderate susceptibility (k = 0.04 SI) but limited depth extent. Examination of the magnetic and radiometric grid data shows strong linear trends, cross cutting dykes and other features that may help in understanding the geology of this area.

As the regional magnetic data on the reconnaissance line was dominated by the responses from the Heazlewood River Ultramafic Complex, an additional reconnaissance line was sited some 30 km to the north (fig. 63). The new line is parallel to the first line and extends from St Valentines Peak, past the Campbell Range, through Edith Creek to Studland Bay in the west. This line has been modelled (schematic interpretation in Figure 64 with H:V exaggeration = 1:5) to agree with most of the conclusions from the earlier line.

The pattern of anomalies from the Arthur Metamorphic Complex is due to multiple, shallow sources with limited depth extent. The sharp anomalies are superimposed on a broad anomaly that may be due to more of the same material (amphibolite?) to a depth of 1500 metres. The gravity data in this area shows the same broad high (of 30 mgal) that is interpreted to be due to the same basement high, again bounded on the west by a flat thrust fault. The Pieman Fault is again concluded to be east dipping.

The Rocky Cape Group extends to the west to the Roger River Fault, although the two data sets indicate that a low gravity and low magnetic zone trends north to south for the full extent of this unit. This zone has been modelled as a 10 km wide low density and low susceptibility facies of the Rocky Cape Group.

The Roger River Fault is indicated by the 500 nT magnetic anomaly related to the Spinks Creek tholeiitic basalt near Edith Creek (340 000 mE, 5 463 000 mN). Another block of the basalt (338 400 mE, 5 464 000 mN), at depth, is interpreted to produce the broad anomaly to the west of the Roger River Fault. The Smithton Basin is reflected by a broad gravity high and quiet magnetic response.

The domal structure at the western end of the traverse has flanking magnetic anomalies, due to outward-dipping basalt units, and a gravity low due to low density metasedimentary rocks in the core of the structure. Between the two magnetic highs the base level is elevated some 100 nT above background and this has been interpreted to represent a deep (1000–2000 m) Cambrian intrusive body.

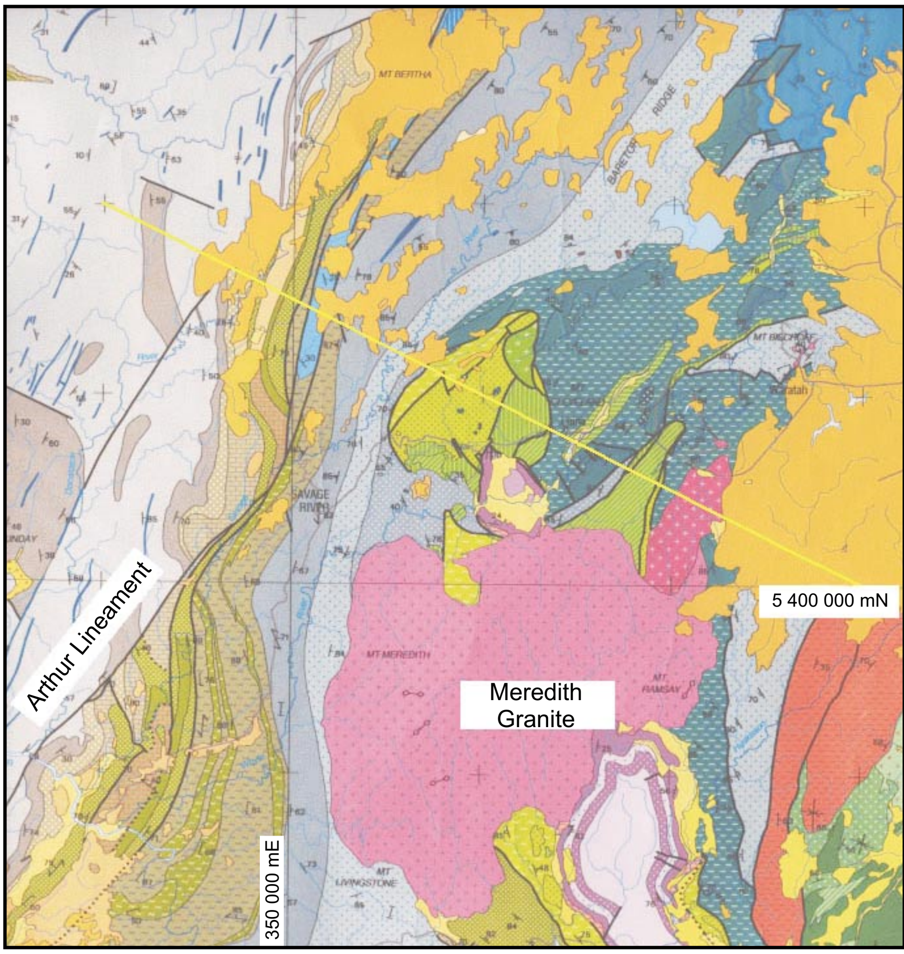


Figure 59
Part of 1:250 000 scale geological map in the vicinity of the Meredith Granite, showing location of reconnaissance profile Arthur_S.

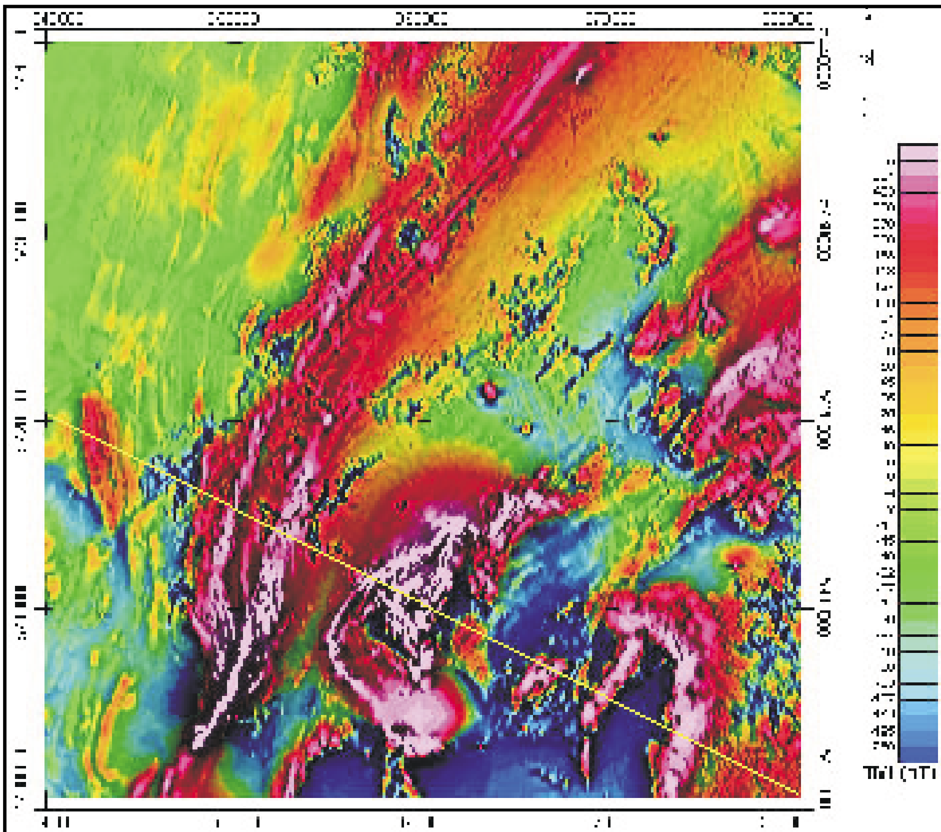


Figure 60
TMI image in the vicinity of the Arthur Lineament and northern edge of the Meredith Granite showing the location of reconnaissance traverse Arthur_S.

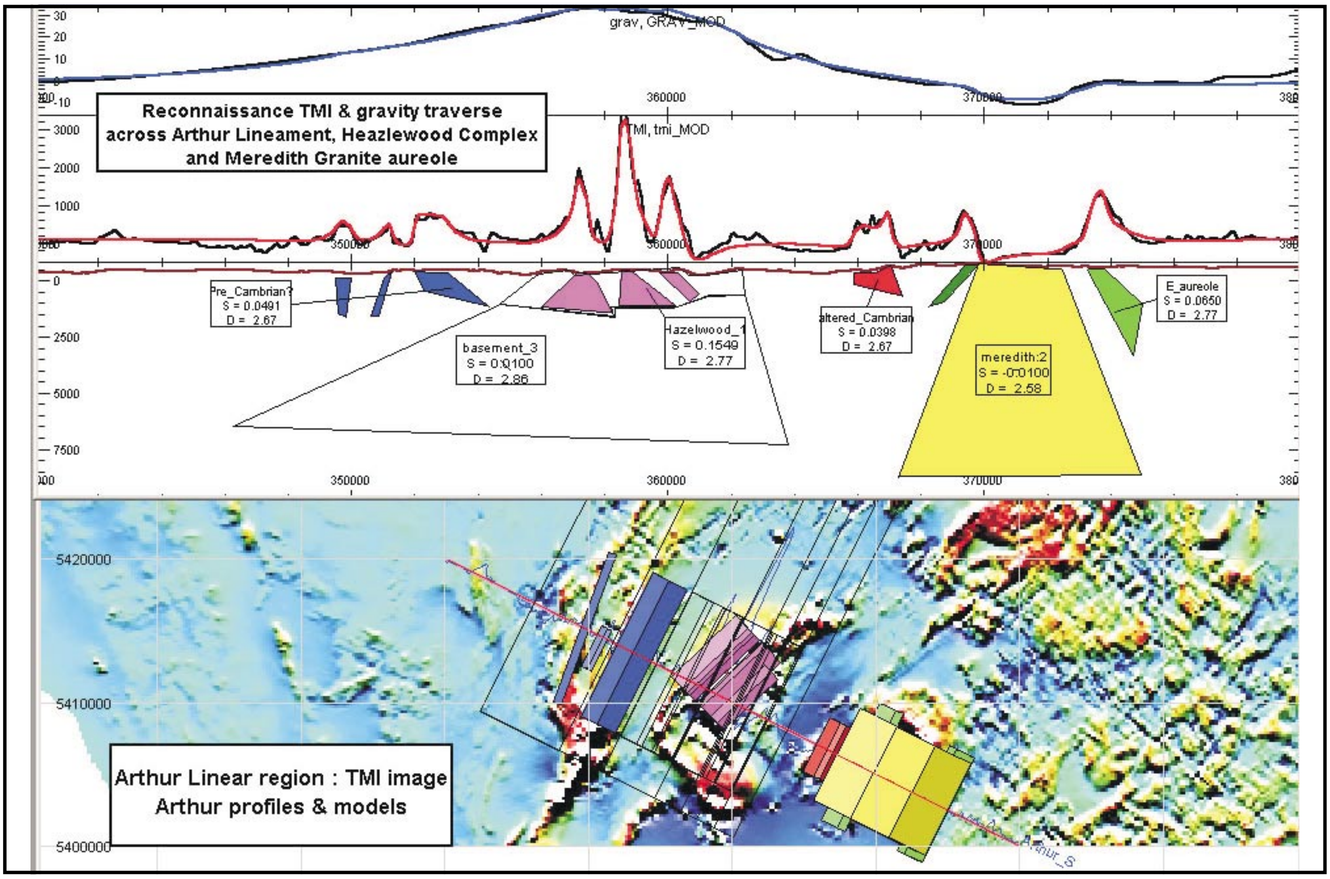


Figure 62

Model of gravity and magnetic data (H:V = 2:1)

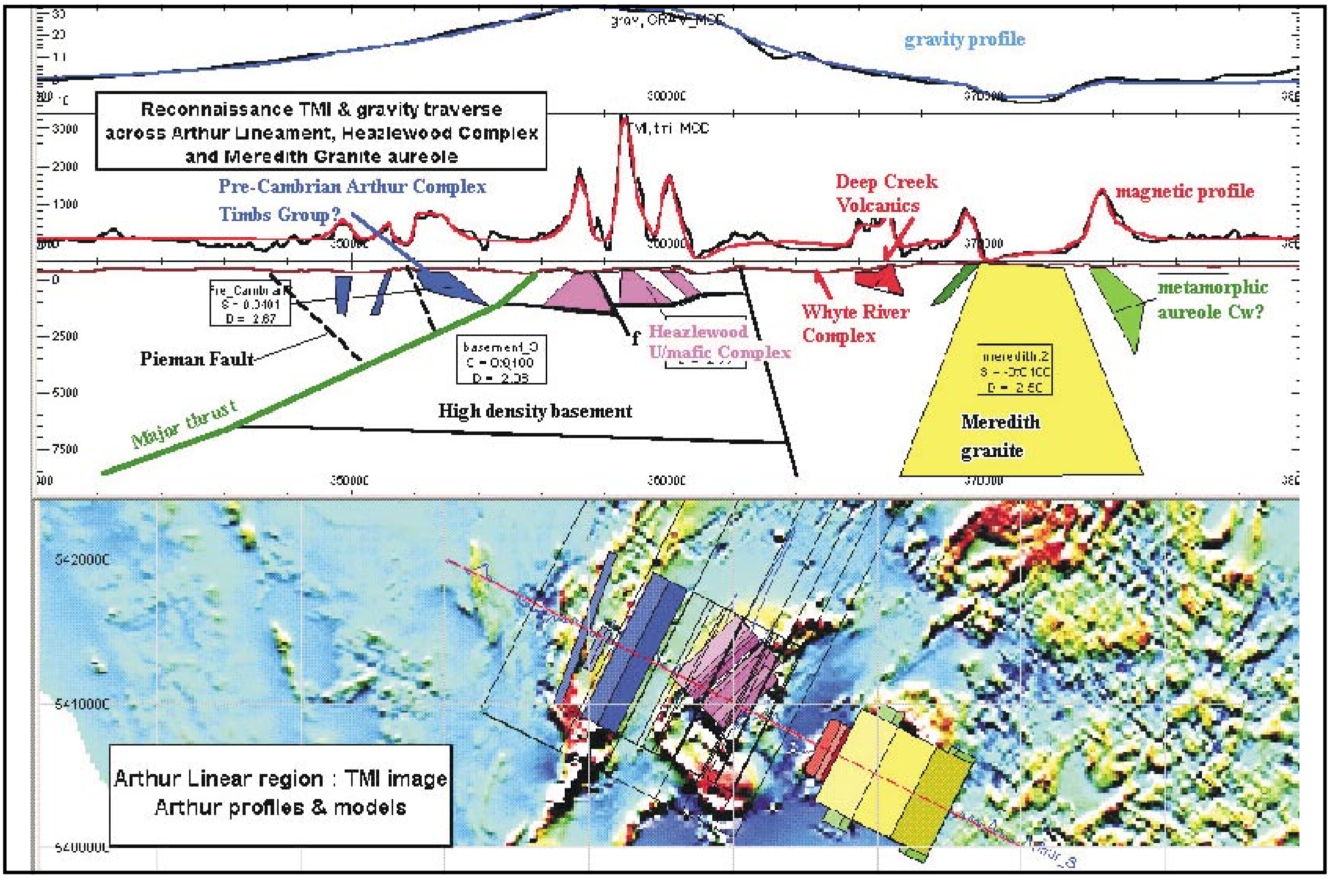


Figure 63

Schematic interpretation of model results (H:V = 2:1)

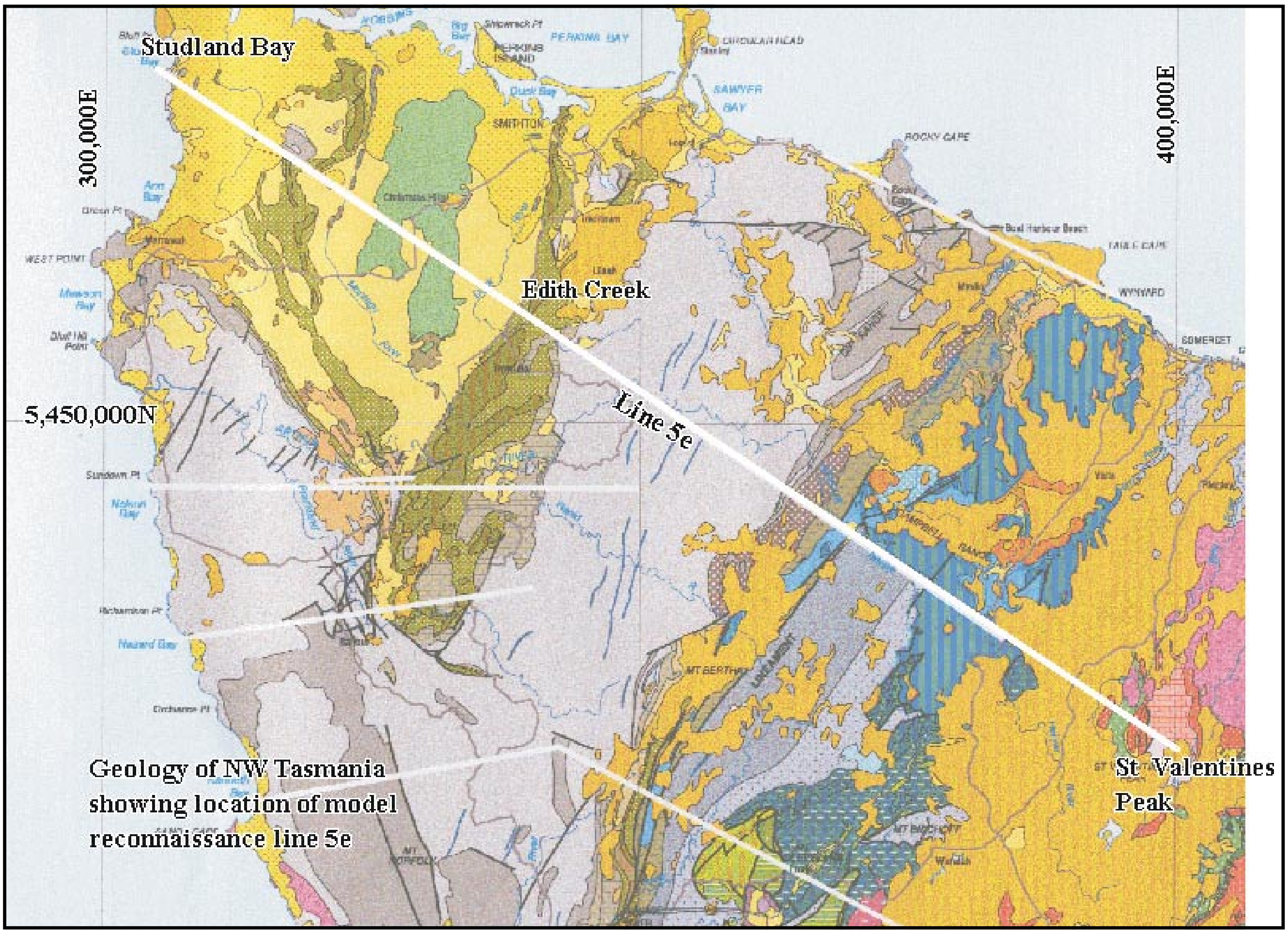


Figure 63

Location map of second reconnaissance line

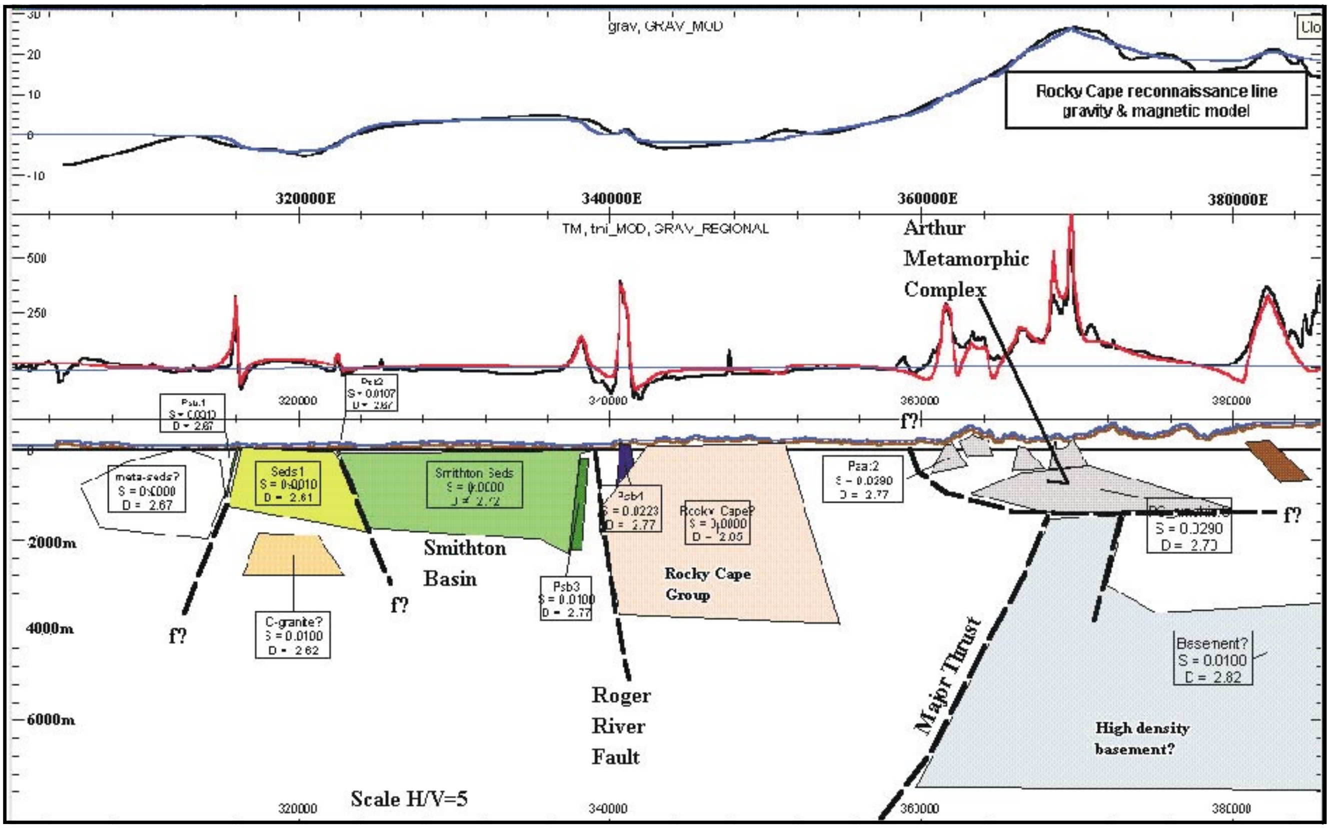


Figure 64

Schematic modelling of second reconnaissance traverse (H:V = 5)

Four reconnaissance lines for modelling were programmed to cross the Balfour district to assist in understanding items of interest in this area where the geology is not mapped in great detail. Of major interest is the movement along the Roger River Fault, aspects of the Balfour Shear Zone, and inferred low angle thrusting in the northwest.

The available data sets include the TMI data (fig. 65), the radiometric data (presented as the Ternary normalisation of the data in fig. 66), and the regional gravity data set.

The relevant subset of the interpolated regional gravity grid is illustrated in Figure 67 and clearly shows major features such as:

- the Smithton Basin is represented as a broad gravity high flanked on the east by a NNE-trending gravity gradient, reflecting the Roger River Fault.
- the Rocky Cape Group is shown as a broad gravity low that is bounded on the east by the strong gradient of the Arthur Lineament.
- the Balfour District, in the southwest, is contrasted as a regional gravity low comprised of a series of NNW-trending linear low zones.

In order to assess the veracity of these anomalies, a subset of the data was re-gridded with 'drop-outs' to show the areas where station density was inadequate to allow interpolation with accuracy. Both data sets are shown in Figure 67, with actual station location superimposed onto the newly generated image. The comparison of these data shows that the regional features mentioned above are preserved, although there are areas where the data sampling is inadequate to resolve some local anomalies. Caution must be given when modelling gravity data in these areas.

Qualitative geological interpretation

Prior to undertaking the modelling of the reconnaissance traverses, the data sets were subjected to qualitative interpretation to obtain a better control of the regional geology assumed to be responsible for the geophysical anomalies. The most detailed geological mapping in the area has been compiled for the Dempster 1:25 000 scale sheet (Everard *et al.* 1999), shown in Figure 68, and the accompanying section was used as a basis for modelling of the TMI data. The Dempster sheet is located at the locus of the most important structural elements of the Balfour district and can best be understood by examining the surrounding TMI data (fig. 69). The strongest magnetic anomalies are due to the Spinks Creek Volcanics (Psb) that are interpreted, from the magnetic data, to be affected by NE-trending dextral faults, which are not evident in the detailed geological mapping. The Psb units continue to the NNE to the east of Roger River Fault (RRF) where the NE–SW compressional faults and folding generate anticlinal windows into the underlying geology and, further north, splay structures that fan the volcanic rocks into the surrounding geology.

A magnetic profile (fig. 70), along the geological section A–C, has been interpolated from the TMI grid data and modelled to fit the outcrop geology and susceptibility data provided by MRT staff. The various basalt units provide the main contribution to the magnetic profile and reasonable fit is observed for the models to the proposed section. The main differences are that the axial plane of the synclinal structure needs to be further to the east and the western limb needs to be tighter. Strong magnetic anomalies to the west of the Frankland River are due to sources that cannot be explained by the known geology; possible sources are outlined later in this discussion.

The qualitative interpretation was then expanded (fig. 71) to the immediate vicinity of the Dempster sheet by extrapolating the known geology using the magnetic and radiometric data. A major fault zone (tentatively named the Leigh River Shear Zone [LRSZ]) that crosses the area in a NW–SE direction terminates the NNE–SSW trend of the Psb and RRF (at the southern limit of the Dempster sheet). The LRSZ is reflected in both the magnetic (fig. 72) and radiometric (fig. 73) data as follows:

- An almost continuous, sharp magnetic high traces out the plane of the fault zone and is correlated with outcrop of a tholeiitic basalt unit. Although this unit is part of the Spinks Creek Volcanics, subtle chemical (J. Everard, pers. comm.) and magnetic property differences indicate that the fault-bound unit is a separate flow to the other Psb units.
- The plane of the fault zone and associated Psb magnetic anomalies appear to wrap around the RRF with a change in trend from NNW to N–S and back to NNW, with a displacement of the order of 20 km to the south. This flexure, and intense faulting mapped in the vicinity, is interpreted to be caused by dextral strike slip transfer movement on the Roger River Fault.
- The grain of linear magnetic and radiometric features in the geology to the north of the shear zone is predominantly NNE–SSW and this changes across the fault zone to a dominantly NNW–SSE orientation with block-like appearance. There is also a distinct change in tone of the Ternary radiometric image from lighter colours to darker colours, together with a decrease in radiometric response.

To the west of this structure the geophysical data can be interpreted into several geological units with distinct signatures.

- The Pedder River Siltstone (Prc) has a bright radiometric response and is a moderate magnetic high.
- The Lagoon River Quartzite (Prs2) appears black in the Ternary image as it has little radiometric and no magnetic response.
- Along the axis of the Norfolk Range is a unit of linear geophysical response with different characteristics. The unit is interpreted from limited geological observation to be the Lagoon River Quartzite, although the narrow magnetic low response is associated with a (reddish) Ternary radiometric response that would indicate potassic alteration. Several strong magnetic highs (~200 nT) are observed to trend discontinuously along the axis of the range and are interpreted to represent altered blocks within the Balfour Shear Zone (BSZ). These units (labelled Prs1) can be traced north along the BSZ to the Roger River Fault (RRF) where they are 'lost' within the fault complex mapped on the Dempster sheet, only to re-emerge and continue to trend NNW for a limited distance (fig. 71).
- Immediately to the east of the Norfolk Range are two arcuate zones of no magnetic response and enhanced (potassic) radiometric pattern, which would normally be interpreted as due to (S-type) granite. As granite is not known in the area, it is interpreted to be present at shallow depth, something to be checked in the modelling exercise. As follow-up is of high priority, it is recommended that whole-rock chemistry of Prs units in the vicinity of the Norfolk Range and the arcuate zones be compared with the chemistry of the Prs units elsewhere, as the geophysical data suggest significant differences should be observed.
- The geophysical response pattern is similar to that observed in the vicinity of the (limited outcrop) Sandy Cape Pluton further to the west. The revised gravity data shows similar linear lows corresponding with both the Sandy Cape Pluton and the Norfolk Range, adding support to this interpretation. (Note: Preliminary images of resistivity data interpreted from a recently flown airborne electromagnetic survey compliment the above interpretation, with a higher resistivity amplitude reported for the Lagoon River Quartzite in the vicinity of the Norfolk Range than reported elsewhere in the survey area).

Quantitative modelling

Traverse A

The southernmost line is located (fig. 71) from south of Kenneth Bay to the Boulder Rivulet area. The western end of the traverse (fig. 74) is over a thin veneer of Lagoon River Quartzite (Prs) that has minor magnetic relief (dykes?) that must be underlain by the Sandy Cape Pluton at shallow depth.

- From 320 500 mE to 326 500 mE a minor gravity high and undulating magnetic profile is reflecting an anticline of the Pedder River Siltstone (Prc).
- From 326 500 mE to 329 000 mE is the Norfolk Range topographic high that exhibits a gravity and magnetic low which is interpreted to be cause by granite at shallow depth.
- The magnetic high at 329 000 mE is interpreted to reflect a magnetic phase of the Prs that has been altered by the intrusive. This unit continues intermittently along the extent of the Balfour Shear Zone, as mentioned above.
- The narrow gravity high (at 330 000 mE) to the east of the magnetic anomaly is interpreted to be due to altered Prs.
- The magnetic and gravity low from 330 500 mE to 333 000 mE is again assumed to be due to shallow granite.
- Further to the east, the line passes into Rocky Cape Group units and the gravity gradient is related to the Arthur Lineament, which is located off the eastern end of the traverse.
- The magnetic high at 342 000 mE is labelled as due to unknown units, however the magnetic image indicates a pattern similar to units of the Arthur Lineament.

Traverse B

This traverse (located in fig. 71) is an extension of the Dempster section AC to the east, and the earlier modelling exercise has been incorporated into the profile (fig. 75).

- The anticline of the Pedder River Siltstone is flanked on the west by two narrow magnetic highs that are assumed to reflect magnetite alteration along NNW-trending faults.
- The gravity stations are widely spaced in the vicinity of the traverse and caution must be given to the interpretation of the data. The profile shows a regional high over the eastern half of the line and a low to the west. The gravity low is flanked by two magnetic highs that are assumed to reflect alteration effects of an intrusive body that is responsible for the gravity low. The eastern magnetic high is the unexplained anomaly on the Dempster section and an intrusive-related alteration may also help explain the source of copper prospects recorded on the Dempster sheet.

Traverse E

Traverse C was not modelled in its original position but was moved to the north to evaluate anomalies in the north of the Balfour District. This profile is labelled 5e1 in Figure 76. The gravity data sample spacing in this area is not sufficient to be used in the modelling.

- In the west, the magnetic pattern of the Proterozoic rocks is relatively uniform, in comparison with the chaotic anomaly pattern in the south, apart from several linear anomalies of cross-cutting dykes. The traverse (fig. 77) shows a broad magnetic high and low that has been modelled as due to a flat unit, of basaltic susceptibility (k = 0.012 SI), from 308 000 mE to 315 000 mE where it is terminated by the thrust fault (suture) that marks the western extent of the Balfour district. The possibility that hydrothermal alteration zones in the basalt could be the source of polymetallic sulphide deposits should be considered.
- Some of the thrust faults that trace the western edge of the Smithton Basin are indicated by magnetic anomalies that are due to steeply dipping Psb units (k = 0.012–0.015 SI) at 315 000 mE and 318 000 mE. There is no reflection in the profile of other thrusts that do not have magnetic material in the fault plane.
- The unit modelled at 321 000 mE has similar susceptibility to other Psb units, the presence of which would be in agreement with geological mapping (J. Everard, pers. comm.)

Conclusions

The main geological units of the Balfour district have characteristic geophysical signatures that allow them to be mapped in detail using the latest MRT airborne data sets. The yet to be released airborne electromagnetic data will provide additional parameters to assist this mapping in an area of difficult access for field verification.

The main developments from the current qualitative and modelling exercise are:

- The interpreted presence of granite at shallow depth along the Norfolk Range and immediately to the east beneath the Lagoon River Quartzite. This interpretation could be checked by whole-rock chemistry of the Prs, as radiometric data suggest chemical alteration of surface lithology.
- Magnetic anomalies on the Dempster sheet, in the vicinity of Balfour, have been interpreted as being caused by contact metamorphism effects in the aureole of this or a similar granite. This result has significance for the source of copper mineralisation in nearby prospects.
- Broad magnetic anomalies in the north of the Balfour district are interpreted to be due to relatively deep (~1000 m deep) flat-lying basalt units. Further interpretation of data in this area may establish the potential for polymetallic sulphide mineralisation.

The Balfour Shear Zone has been correlated with a magnetic anomaly that allows the shear zone to be traced to the north, beneath cover. Magnetic anomalies in the north of the district may be related to this zone or related structures.

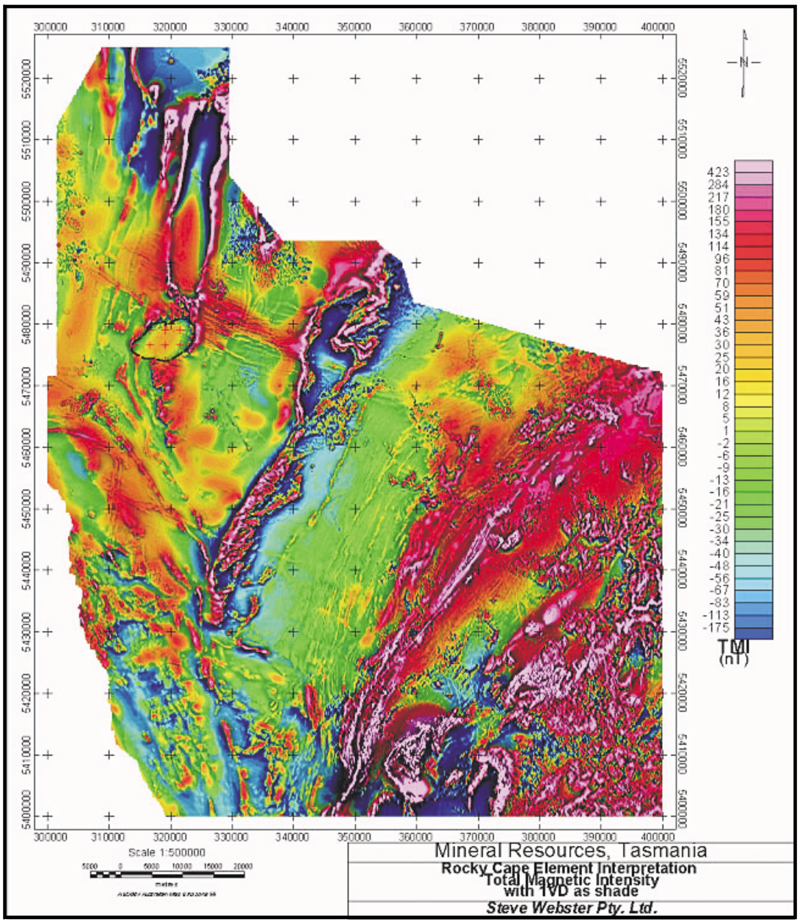


Figure 65
TMI data for Rocky Cape and Balfour District, northest Tasmania

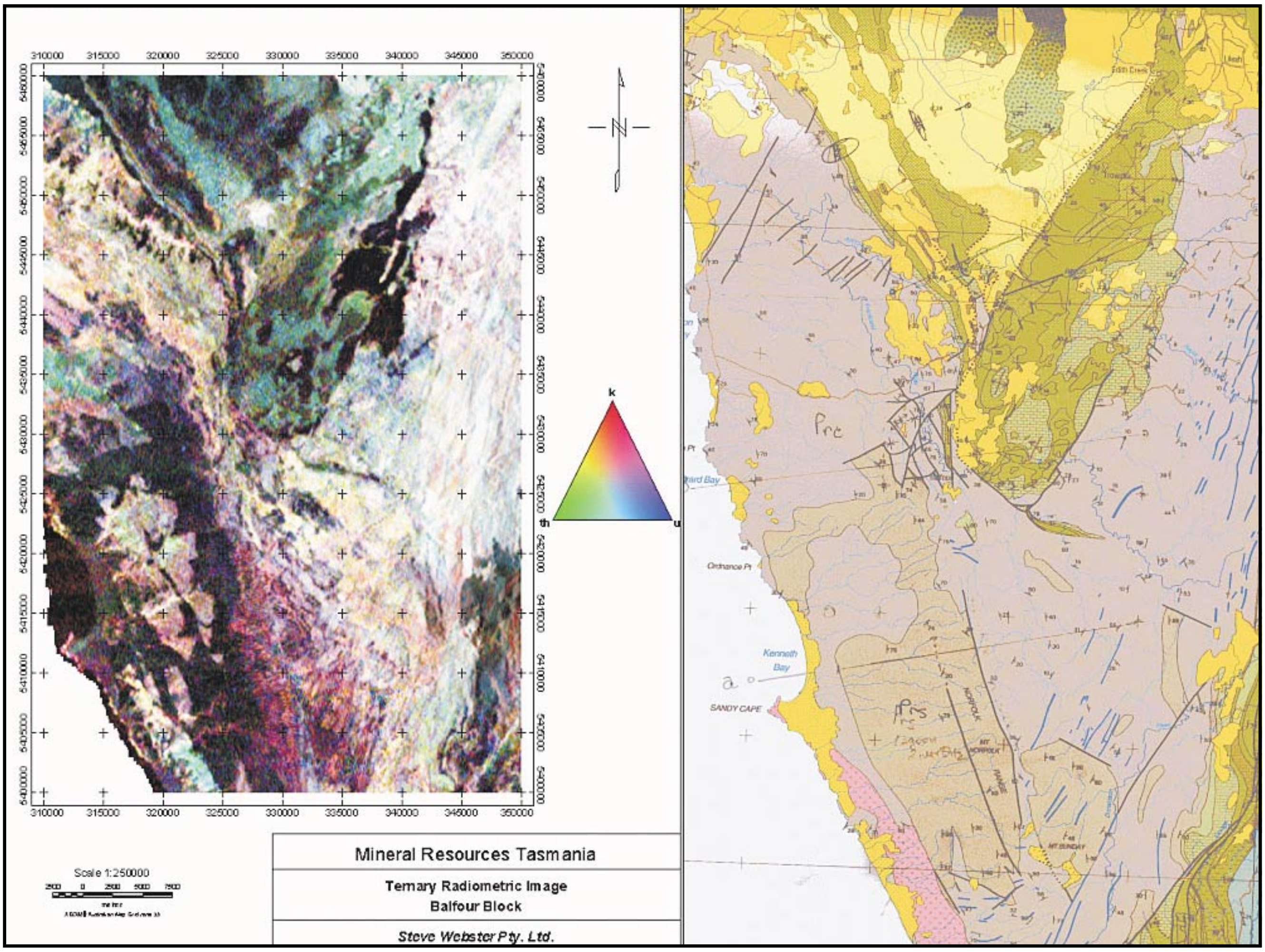


Figure 66. *Radiometric data and 1:250 000 scale geology, Balfour District*

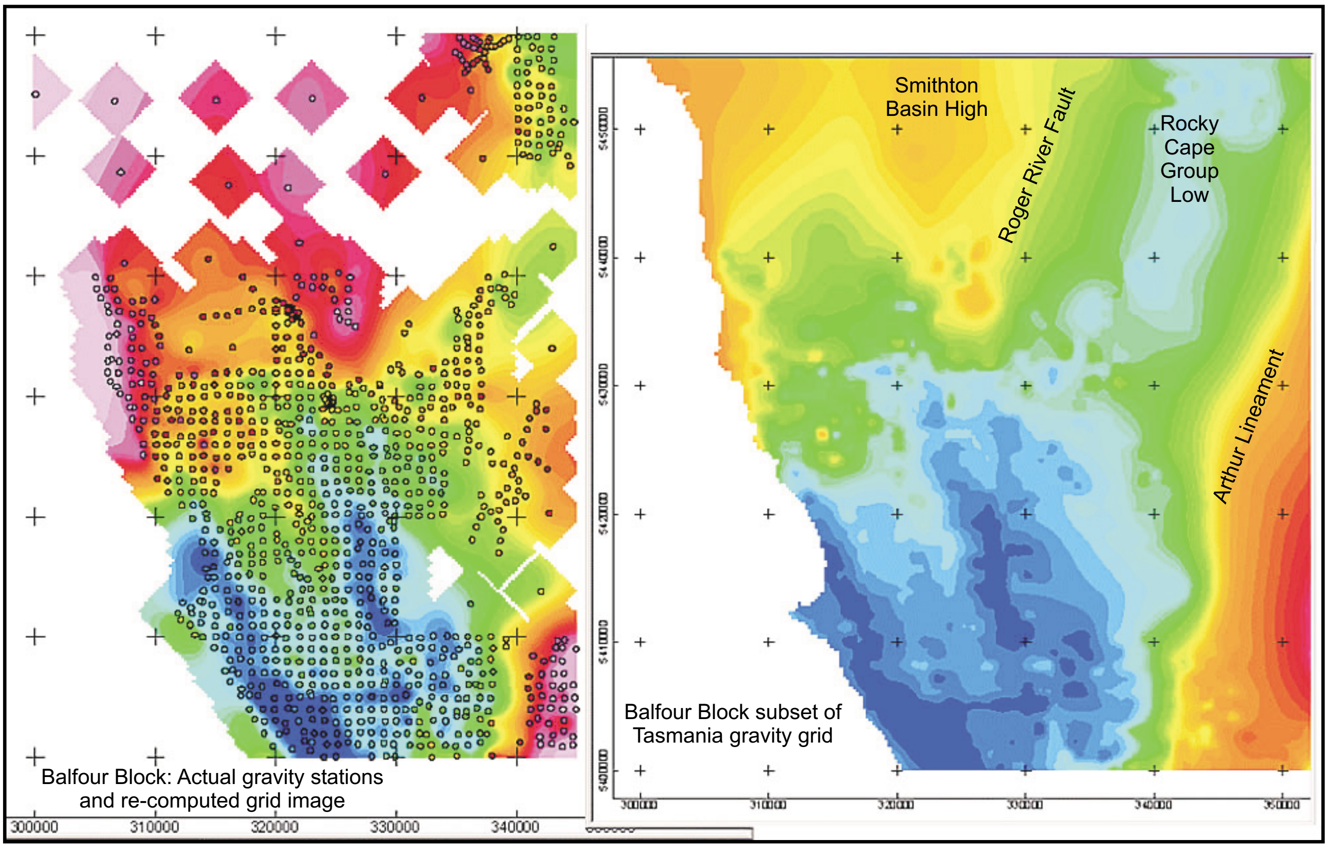


Figure 67
Regional gravity data and station locations, Balfour District

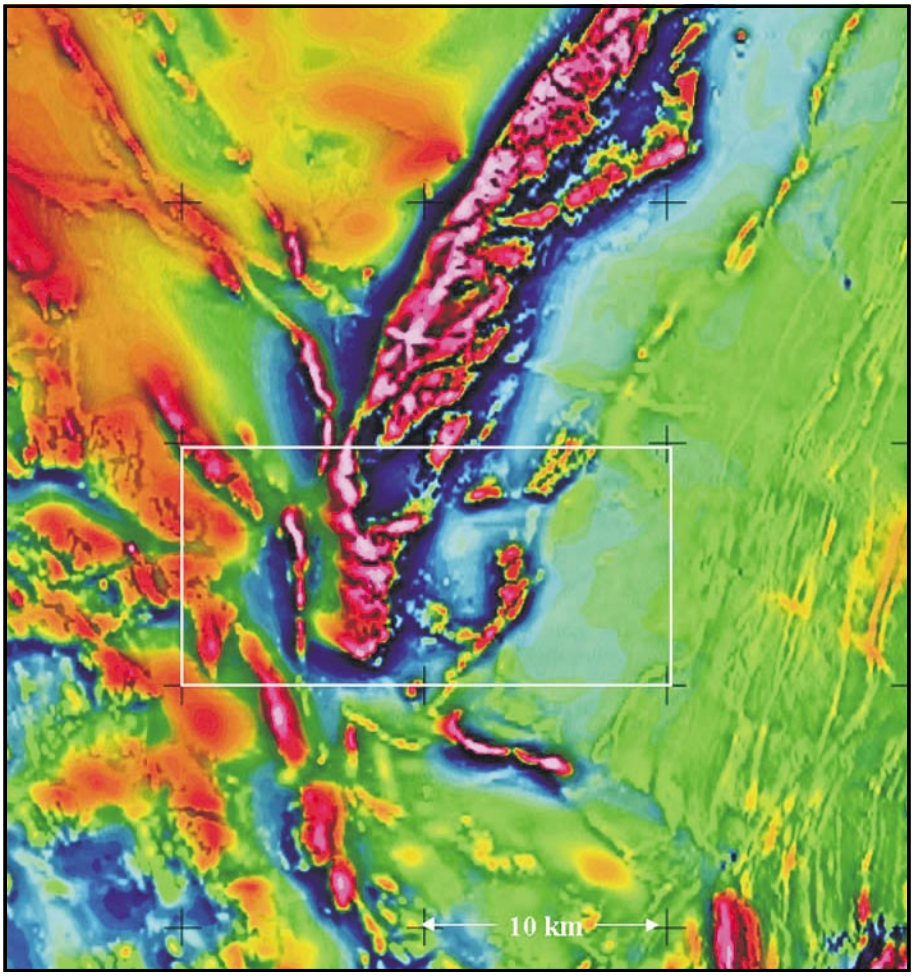


Figure 68
TMI image of data surrounding the Dempster 1:25 000 scale map sheet

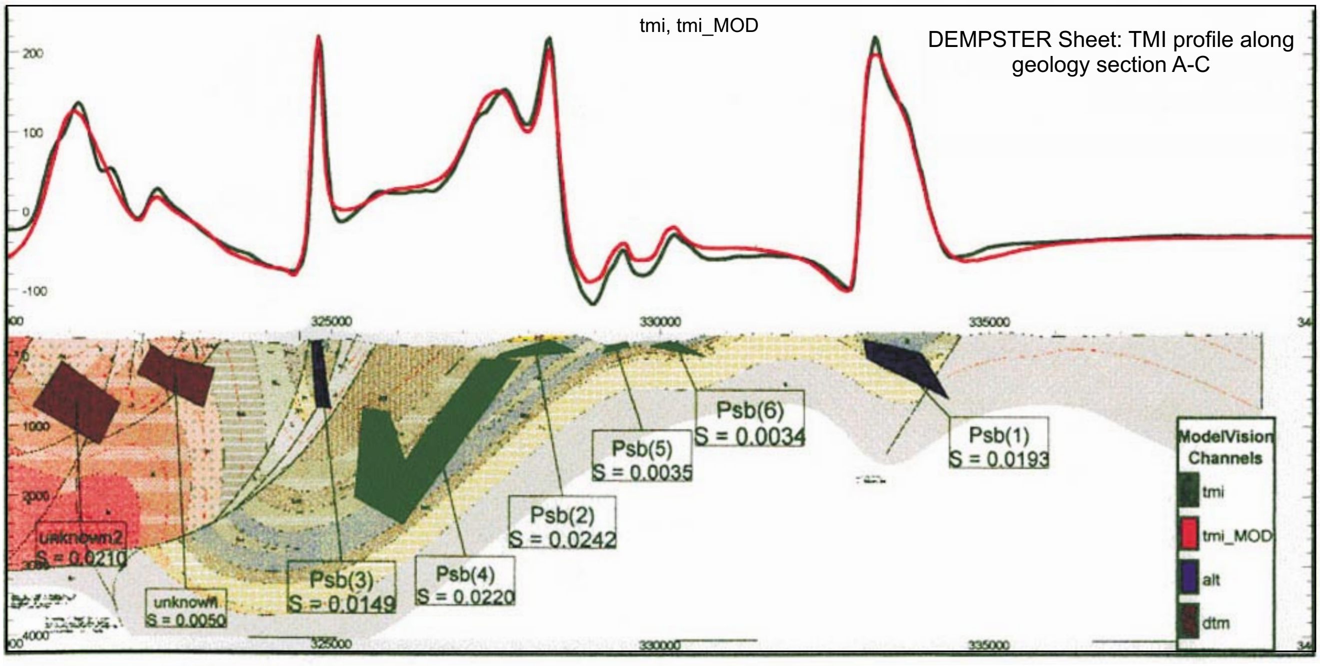


Figure 69
Section Dempster A-C interpreted from TMI data superimposed on published geology section

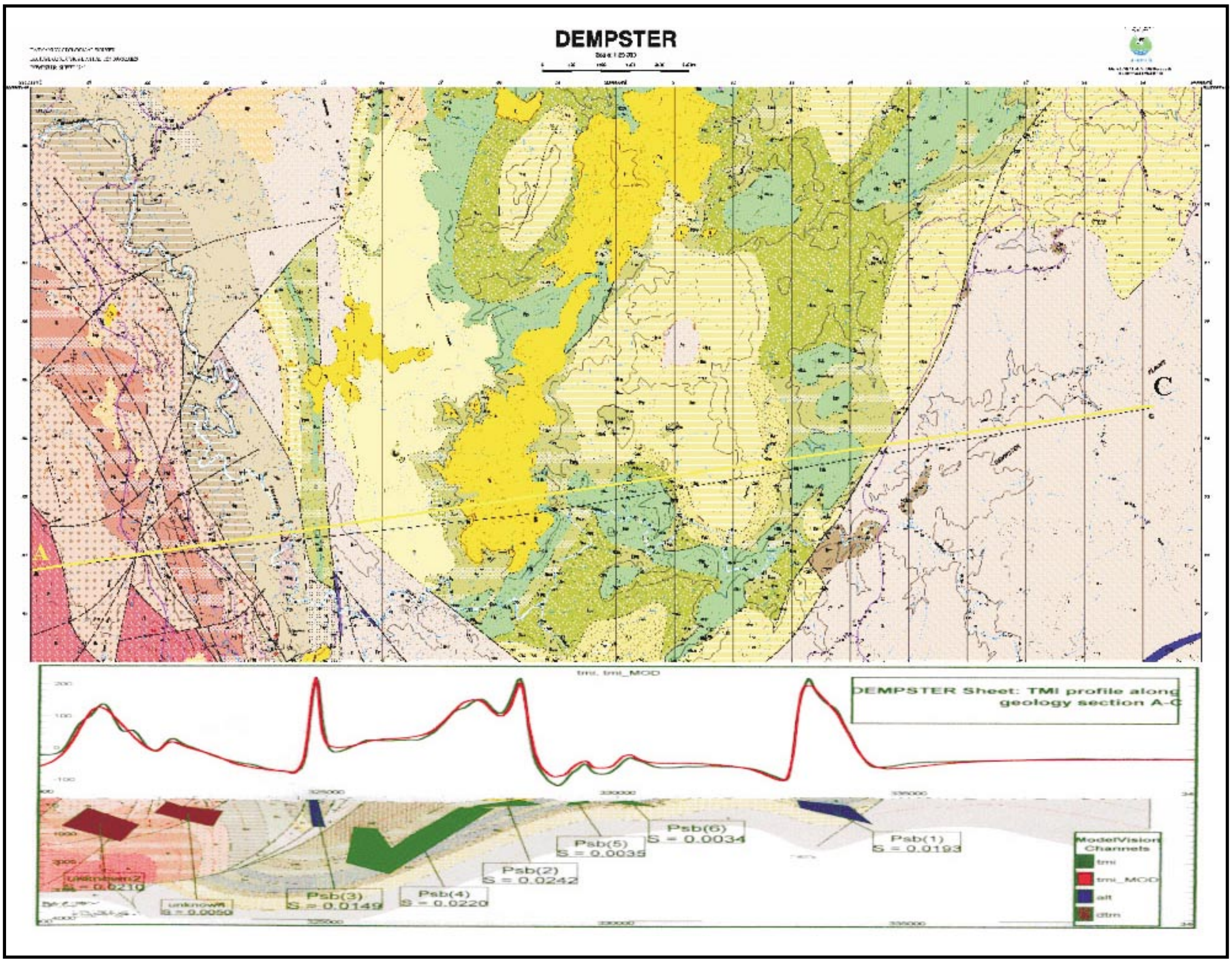


Figure 70
Dempster geology sheet and TMI model section

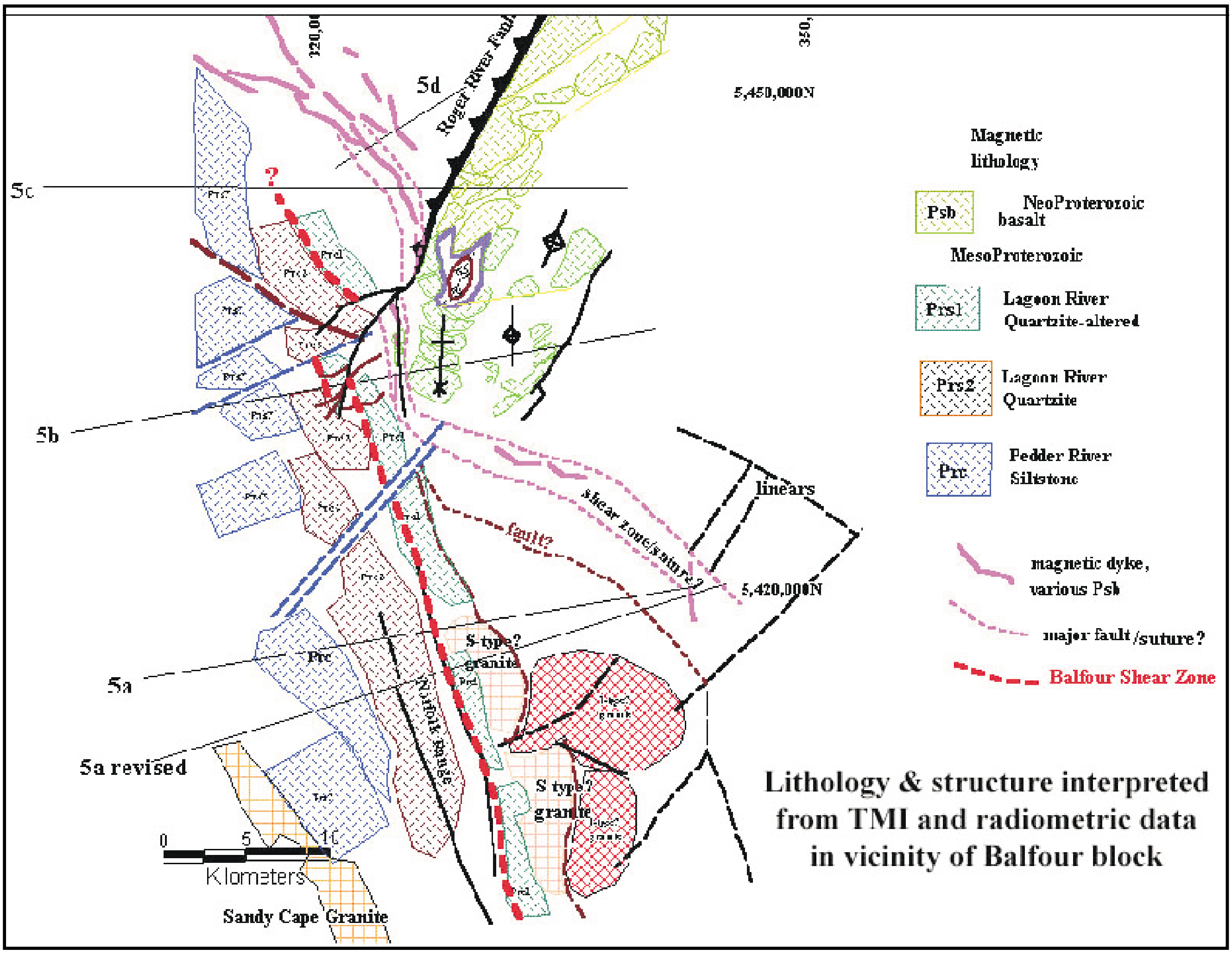


Figure 71

Geology of Balfour district interpreted from geophysical data

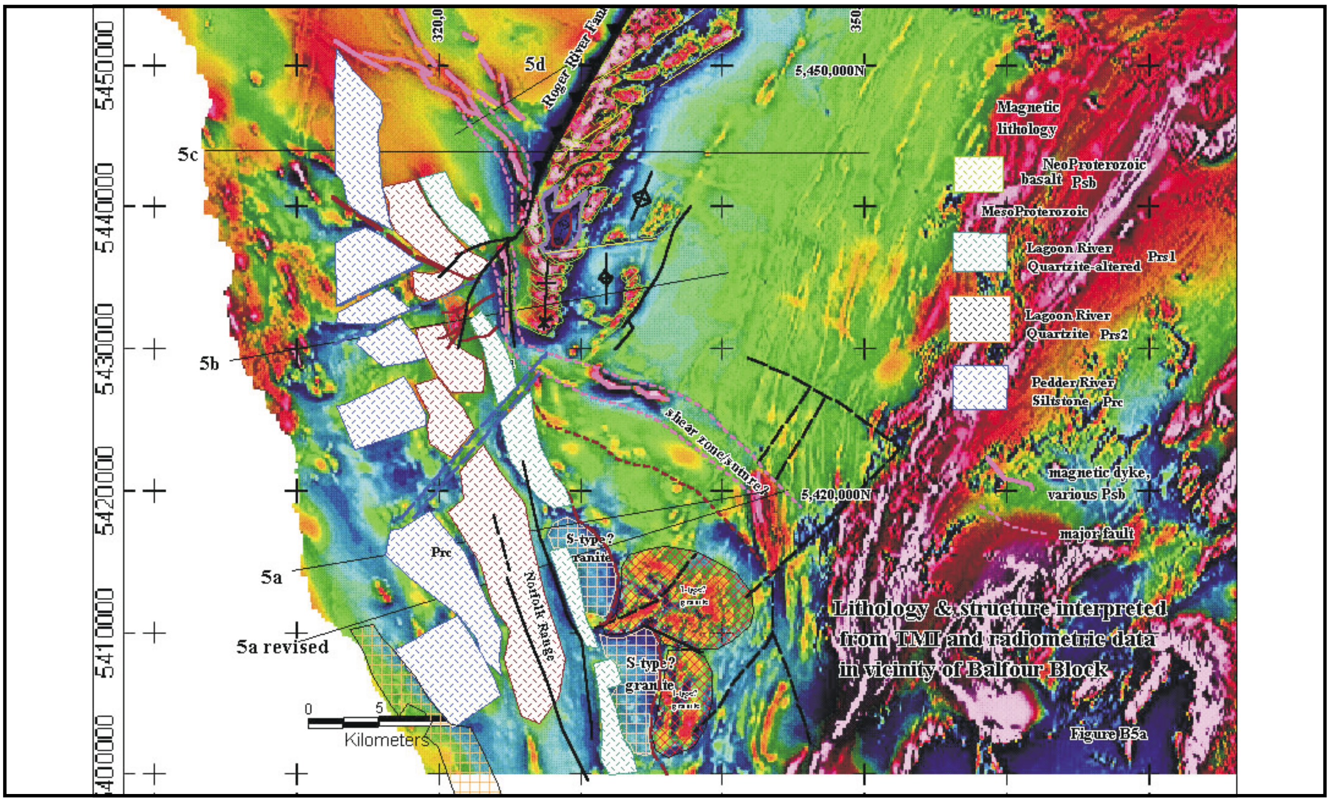


Figure 72

TMI data and geological interpretation, Balfour district

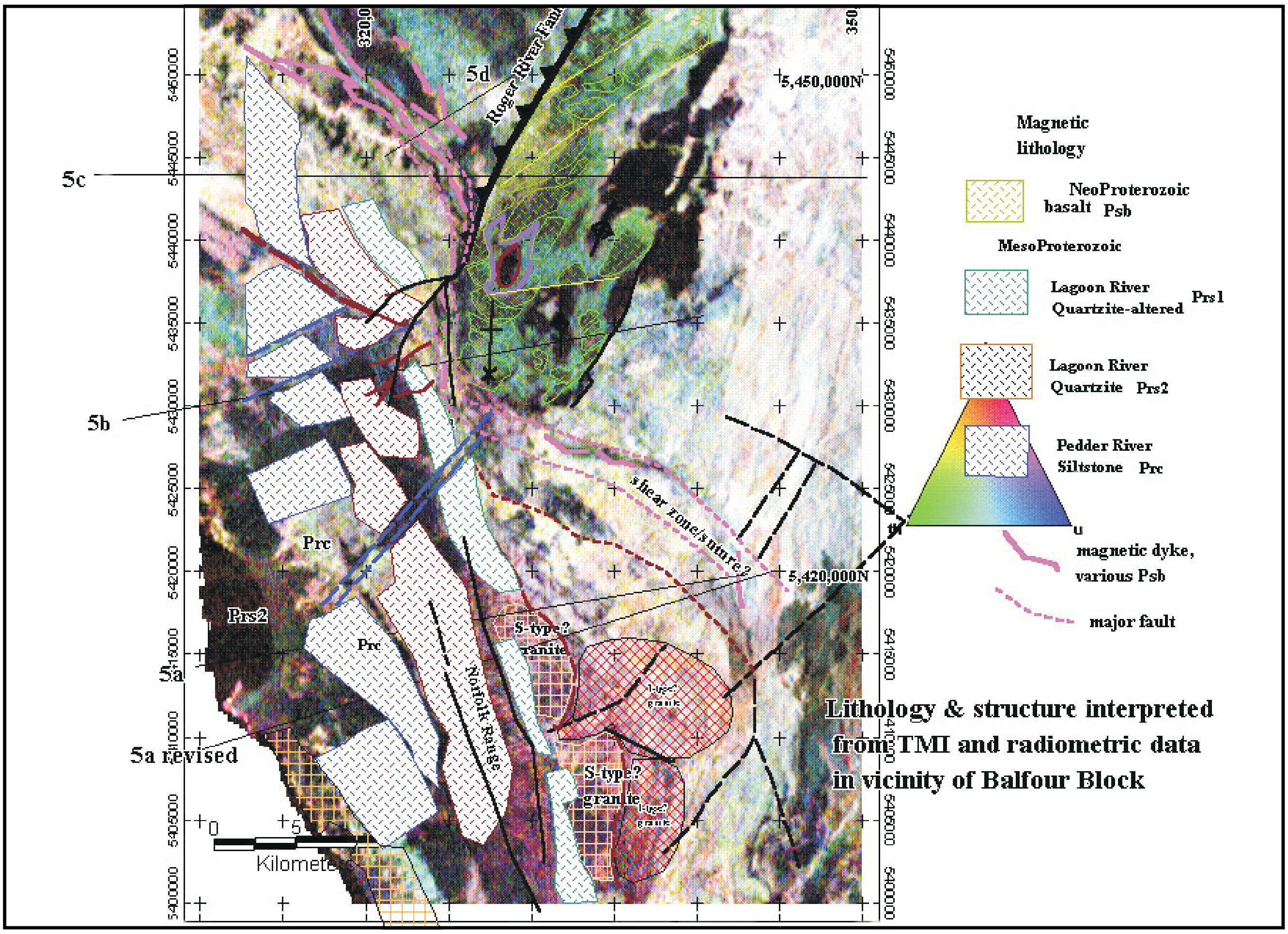


Figure 73

Radiometric data and interpreted geology, Balfour district

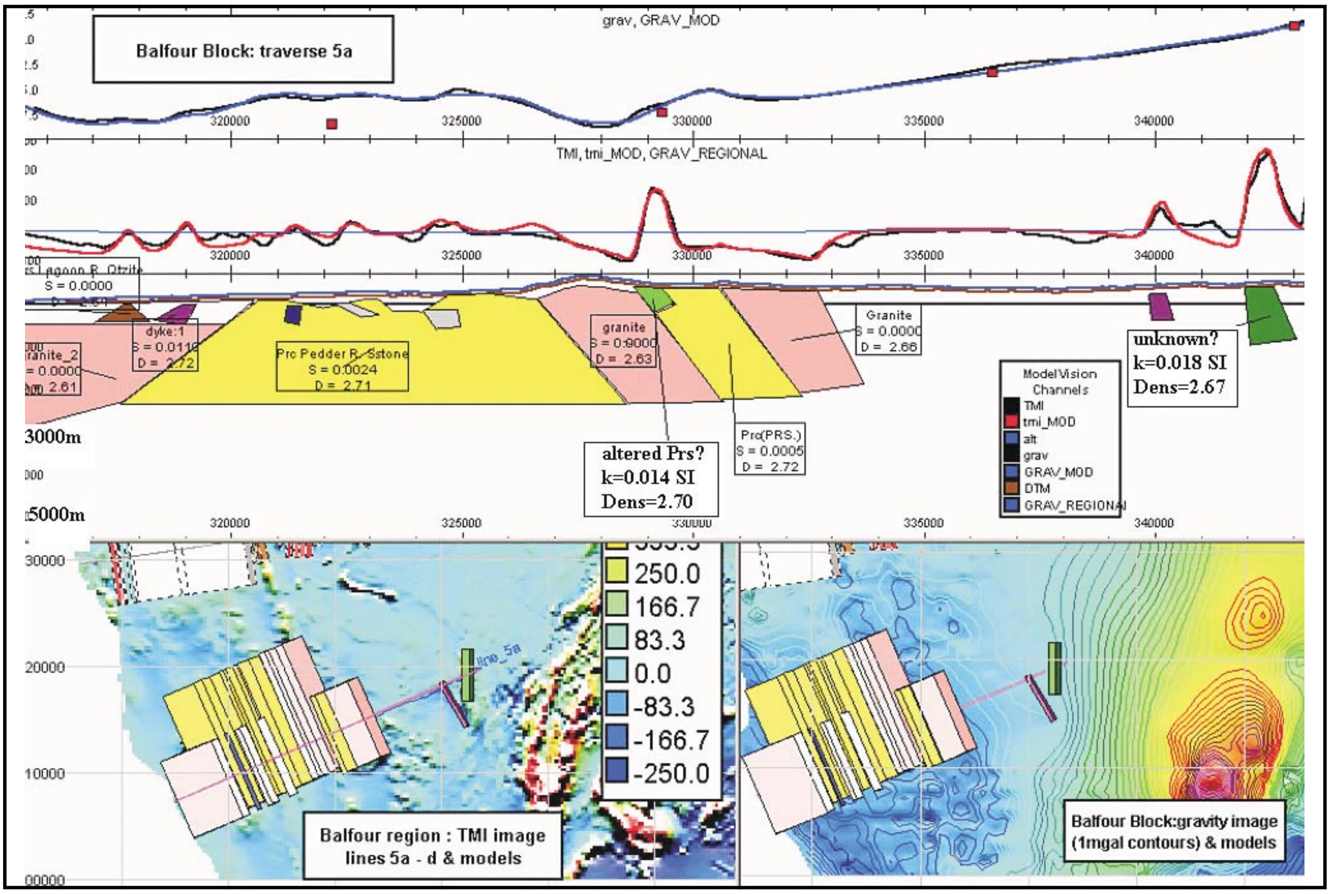


Figure 74

TMI traverse A and model results, Balfour District

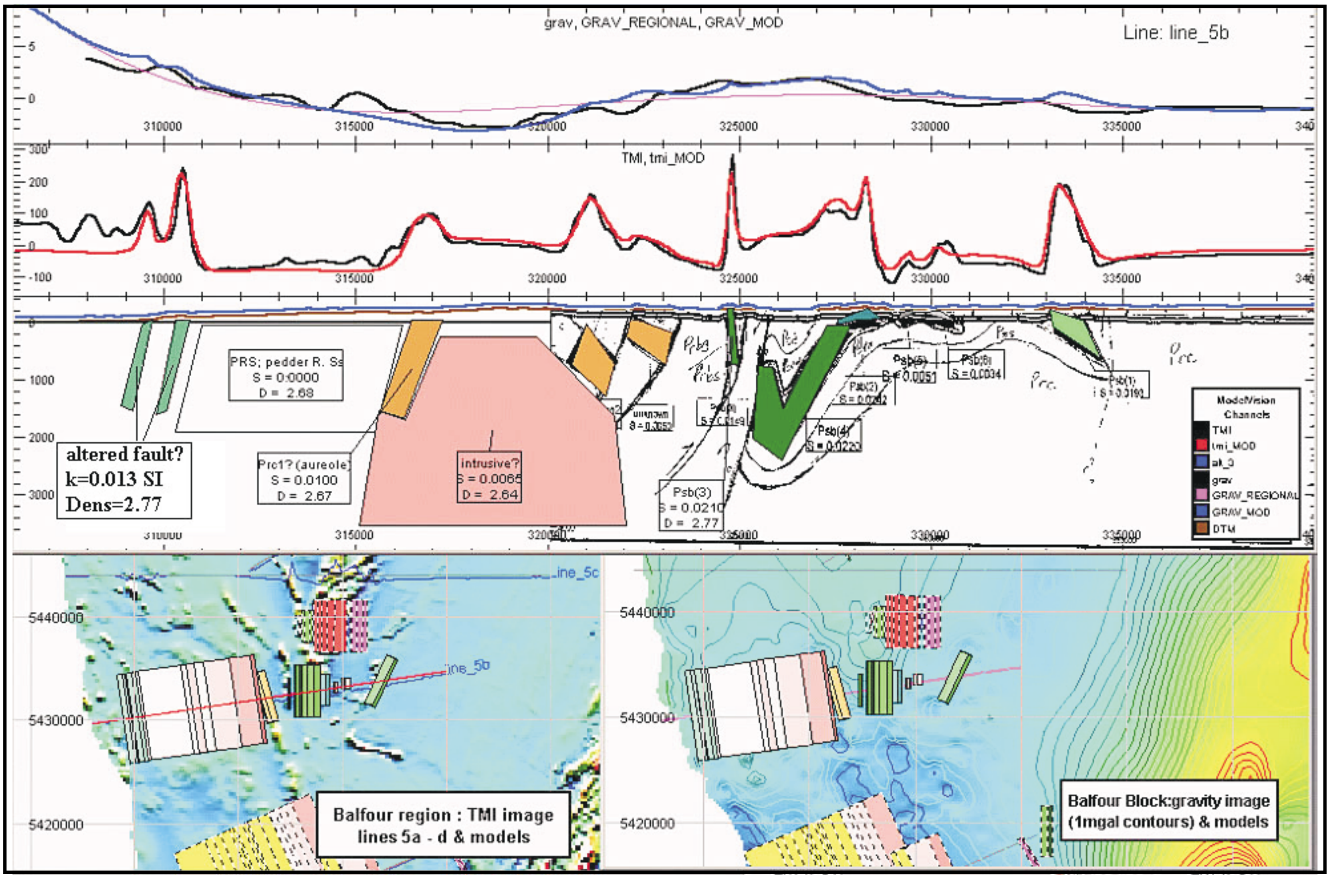


Figure 75

TMI traverse B and model results, Balfour District

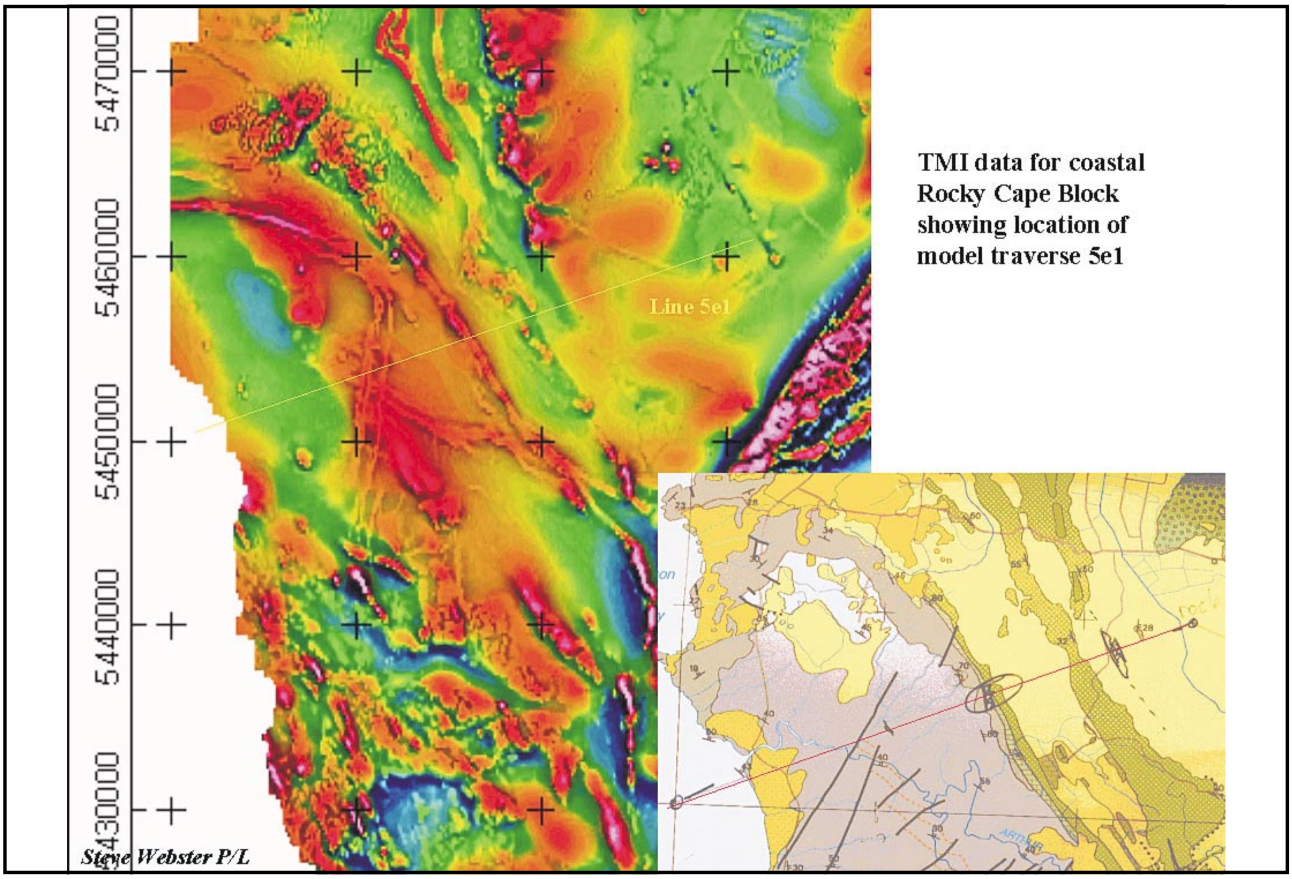


Figure 76

TMI image and geology map showing location of Traverse 5e1

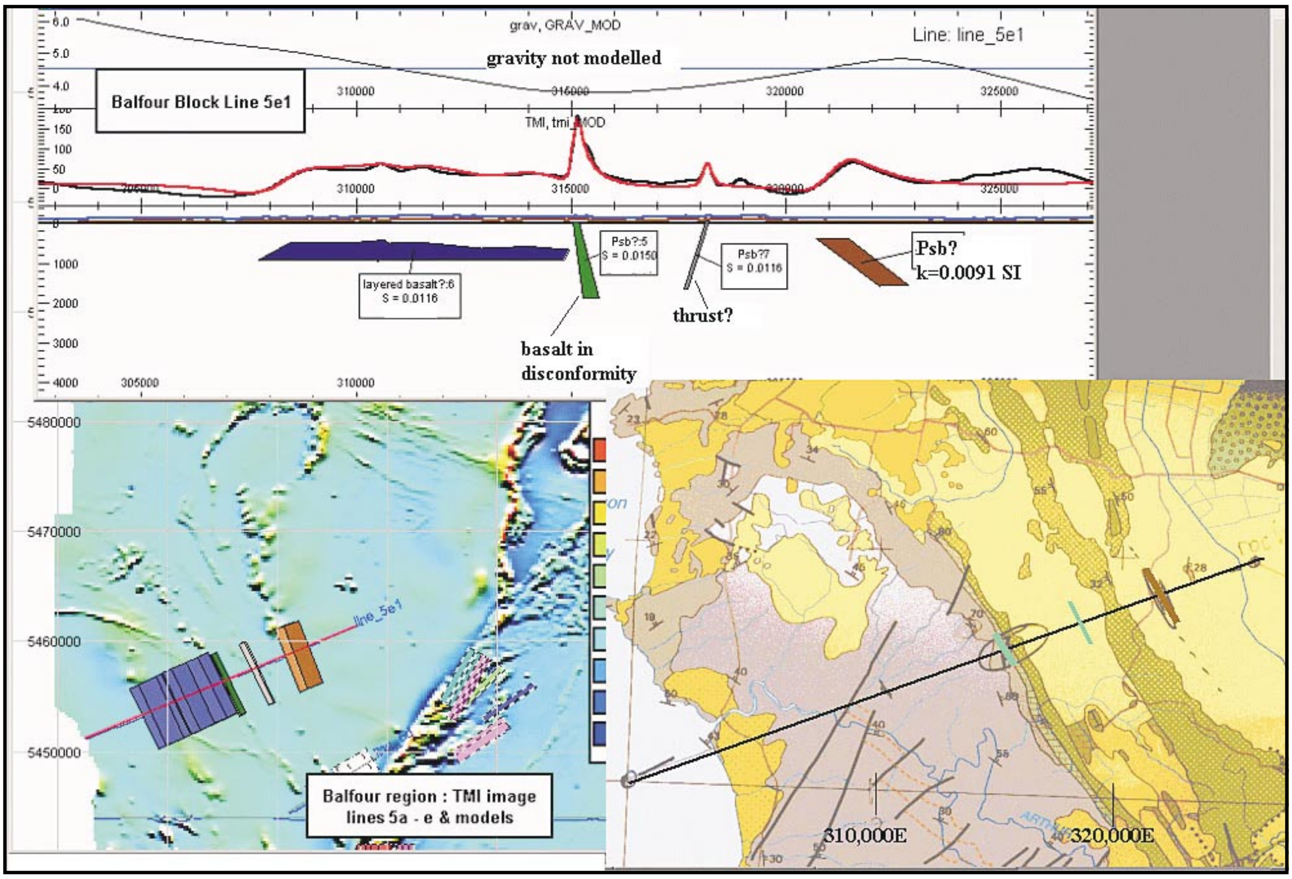


Figure 77

TMI profile and model results for traverse 5e1

Nature and implications of the Meredith aureole

The new MRT airborne geophysical data (fig. 78) show that the Meredith Granite is surrounded by a metamorphic aureole that is reflected by both magnetic and radiometric anomalies. The anomaly patterns extend up to two kilometres into the surrounding lithology and vary in intensity depending on the reactive nature of the units. The magnetic response is caused by thermal metamorphism setting a remanent component in magnetite or pyrrhotite that is complementary to the Earth's induced magnetism (Clark, 1984). The radiometric response is due to geological changes produced by thermal metamorphism, which in some cases is associated with increased fluorine and uranium content. The metamorphism can develop skarn-type mineralisation and the geophysical anomalies can be utilised to target exploration (Webster, 1984).

The geophysical anomalies in several localities around the granite (fig. 79) are discussed below in order to quantify these responses or indicate the presence of lithologies that may be favourable for exploration. Gravity data are regarded as too widely spaced to be used in the modelling.

Huskisson Syncline

The north-trending Huskisson Syncline, of Siluro-Devonian sedimentary rocks, is located in the southeast 'corner' of the Meredith Granite. These sedimentary rocks are unconformable on Early Cambrian (Ꞓsd) dunite, peridotite, pyroxenite and gabbro that are variably serpentinised, and which crop out on both flanks of the syncline. It is inferred in the AGSO seismic interpretation that the ultramafic units are not contiguous under the syncline. The ultramafic rocks are not well exposed in the east flank of the syncline, and the sedimentary rocks may be unconformable with the Cambrian volcaniclastic siltstone and mudstone units that also contain minor carbonate and basalt (Ꞓw). The ultramafic rocks are unconformable with the Precambrian Crimson Creek Formation (Pdv) in the southwest.

Three TMI traverses have been interpolated from the magnetic grid for modelling of the attitude of the ultramafic units. Traverse Csd-1 (fig. 80) is located in the southeast nose of the syncline and is aligned ENE to be normal to the anomaly trend. The western Ꞓsd is inferred to have an apparent susceptibility of 0.2 SI and be steeply dipping, with the eastern Ꞓsd (?Ꞓw) having a much weaker value of 0.086 SI, and also to be steeply dipping. This interpretation agrees with the AGSO seismic interpretation that the ultramafic units are not contiguous under the structure.

Traverse Csd-2 (fig. 81) is located across the southwestern limb, within the metamorphic aureole, and extends across the Crimson Creek units near Mt Lindsay. This interpretation shows a strongly magnetic ultramafic body (k = 0.381 SI) that has limited depth extent (<1 km), perhaps indicating granite at depth. Several strong magnetic anomalies (700–1000 nT) are observed over units of the Crimson Creek Formation (Pdv) that normally only exhibit weak magnetic properties. It is interpreted that the apparent susceptibility of these units is 0.09 SI and that the increased response is due to remanence introduced by thermal metamorphism. Samples from the Mt Lindsay prospect (D. Clark, pers comm) confirmed that both skarn and Pdv units carried a remanence component, with the ratio of remanent to induced magnetism up to 100 times.

Traverse Csd-3 is an east-west traverse located on the broadest anomaly in the eastern flank of the syncline. The interpretation indicates a shallow wedge of the ultramafic rocks coming close to surface, with the same material widening out to several kilometres width at depth. This model would equate to the Ꞓsd forming the eastern limb but not continuing across the base of the structure, as shown in Figure 82.

Implications from this data analysis include:

- The apparent susceptibility of the ultramafic rocks and the Crimson Creek Formation are significantly enhanced in the vicinity of the granite, due to metamorphic effects.
- Anomaly patterns may be utilised to locate prospective zones where shallow granite has created metamorphic aureoles that may contain mineralisation.
- The ultramafic body is not always contiguous under the Huskisson Syncline.

NW Meredith

The northwest 'corner' of the Meredith Granite intrudes Neoproterozoic to Cambrian units with potential for skarn mineralisation. These units include the Proterozoic Oonah Formation (Po), Cambrian serpentinised dunite (Ꞓsd), Eocambrian correlates of the Success Group (Esq) and perhaps correlates of the Crimson Creek Formation (Ecc) (Brown, 1986).

Geophysical data for this portion of the granite (fig. 83) show the batholith to be multi-phased with a wide range of radiometric responses. The magnetic data are complicated by very strong responses (>1500 nT) from the Heazlewood Ultramafic Complex, with the negative portion of this dipole extending well to the south of the contact. The serpentinised dunite (Ꞓsd) exhibits an anomaly complex pattern of linear highs and lows with >500 nT relief, that is less than would be expected for such units. The western flank of the granite is characterised by linear magnetic anomalies (>4 km long) that wrap around the northwest 'corner' of the granite, and extend almost two kilometres into the flanking Esq and Pws units.

Several TMI profiles have been modelled in an attempt to quantify the apparent susceptibility parameters of the units and analyse the anomaly patterns. A modelled N–S profile (360 000 mE) across the Mt Stewart Ultramafic Complex (Ꞓsd) (fig. 84) indicates a high apparent susceptibility (0.156 SI) and if remanence is present it must be aligned with the Earth's current magnetic field (i.e. compatible with Devonian metamorphism). This apparent susceptibility is in the range observed for Ꞓsd in the analysis of other profiles. The trend of this strong anomaly follows exactly the mapped outcrop (Brown, 1986) of the Ꞓsd contact with Esq and implies metamorphosed Ꞓsd as the source rather than ultramafic material, as earlier assumed.

Analysis of E–W profiles (fig. 85) shows the southern part of Ꞓsd to have lower apparent susceptibility (0.04–0.05 SI) and limited depth extent, thus granite underlies this outcrop. The negative anomalies of this complex are modelled as forming part of the dipole pairs and not representative of late-phase, strong skarn effects, as observed at Renison and Zeehan.

The anomalies at the western contact of the granite (353 000 mE) show susceptibility values in the range of 0.04–0.05 SI in the vicinity of mapped dolerite (Pd) within the Oonah Formation. These apparent susceptibility values are compatible with values interpreted for Crimson Creek (Pdv) units in the vicinity of Renison and Mt Lindsay and the anomalies may indicate that Pdv units are indeed present in this area.

Units of the Arthur Lineament

Units of the Arthur Lineament are mapped in close proximity to the western contact of the Meredith Granite, but are generally outside the two kilometres of the metamorphic aureole. A profile of TMI and radiometric data has been interpolated along 5 396 000 mN (fig. 86) to demonstrate the variable responses of the units of the Arthur Lineament.

The very strong magnetic response (>10,000 nT) of the amphibolite is modelled as a thin (~200 m wide) wedge of high apparent susceptibility (k = 0.8 SI) that is equivalent to a magnetite content of the order of 15%. A similar interpretation (k = 0.7 SI) is derived for modelling of the same unit on a profile at 5 390 000 mN where the unit is in closest proximity to the granite (~2 km), thus no effect of thermal metamorphism is observed.

Figure 86 also includes profiles of radiometric data, which clearly illustrate where the profile crosses the granite contact with a strong increase in response for all three channels. Some variation in radiometric response is observed along the profile that can be equated to changes in geology, as mapped on the Corinna 1:50 000 scale geological map sheet (Turner *et al.*, 1991). Variation in magnetic response is observed on the profile that can be correlated with the various Arthur Lineament (e.g. Pbb) units, although these anomalies have not been modelled.

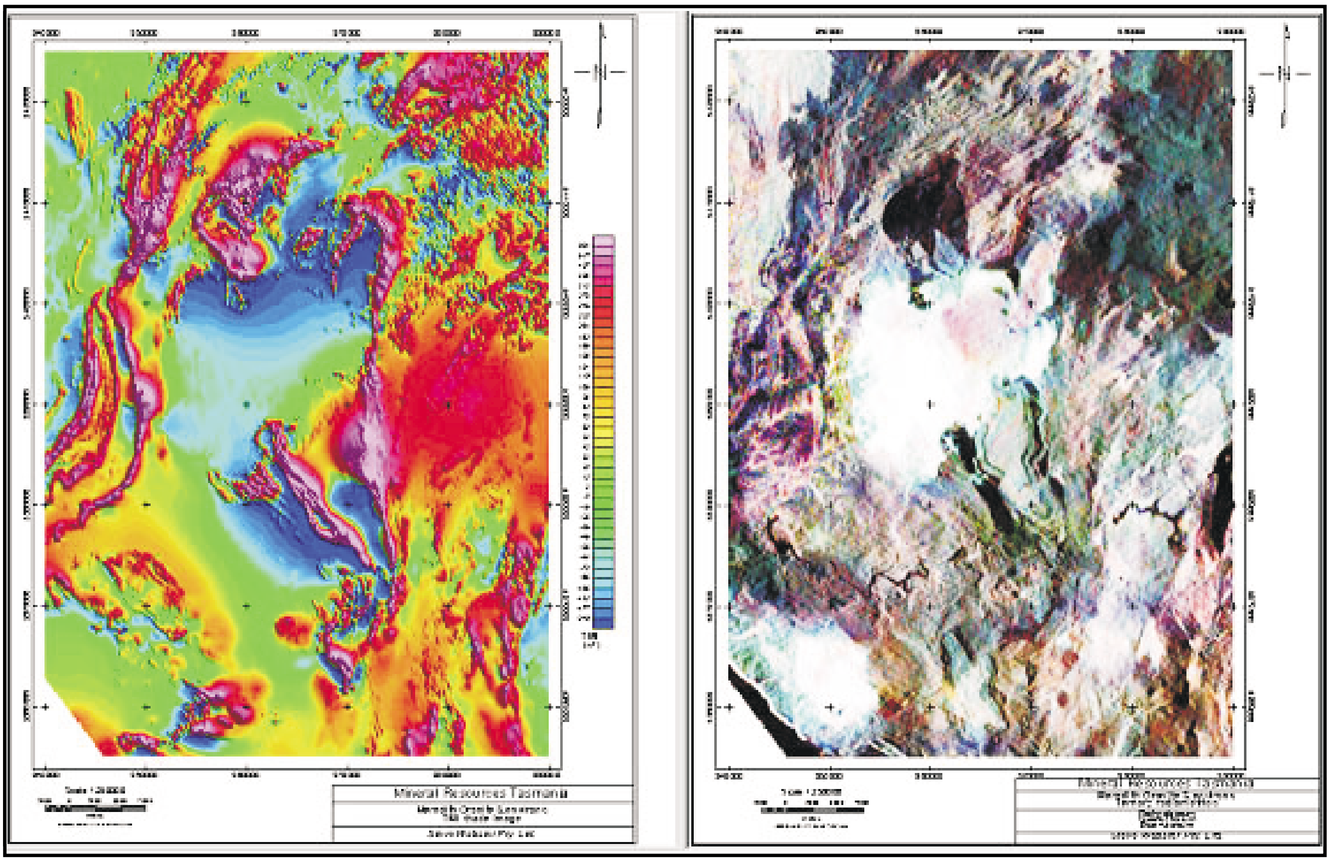


Figure 78

Magnetic and radiometric data in vicinity of the Meredith Granite

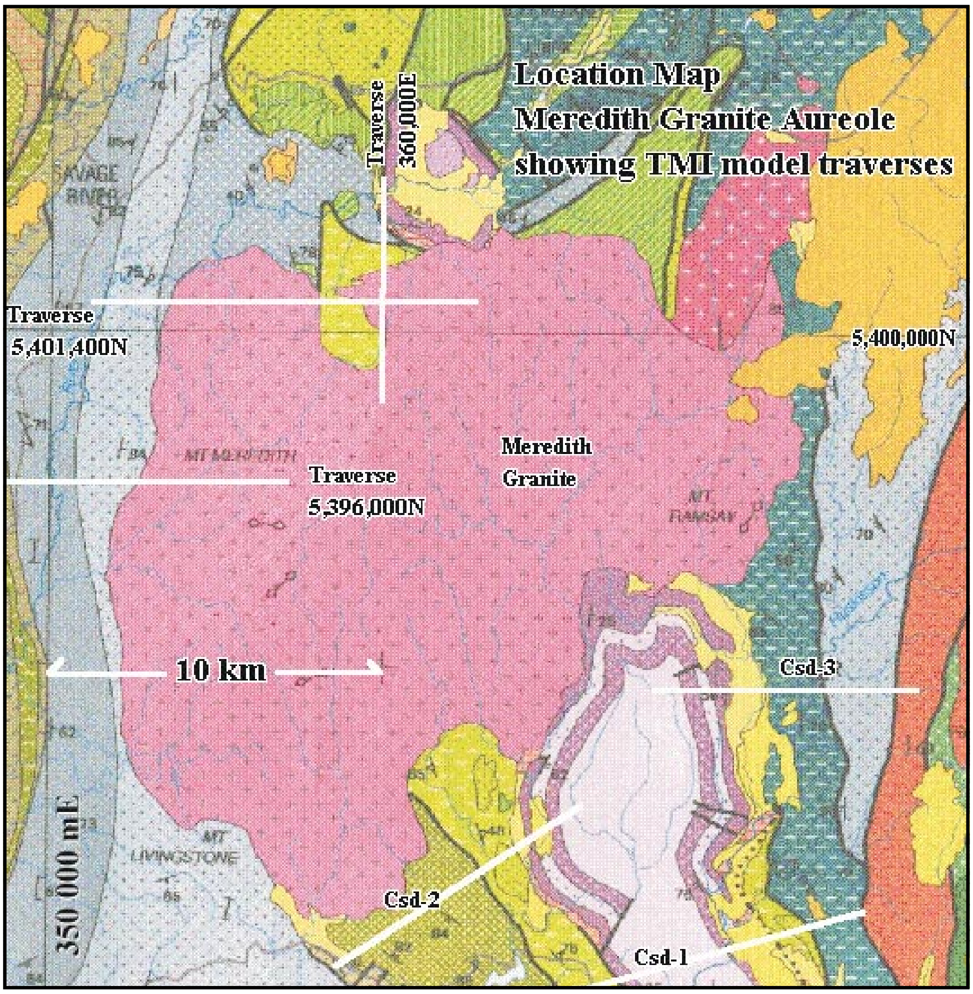


Figure 79

Geology map of Meredith Granite, showing location of model traverses

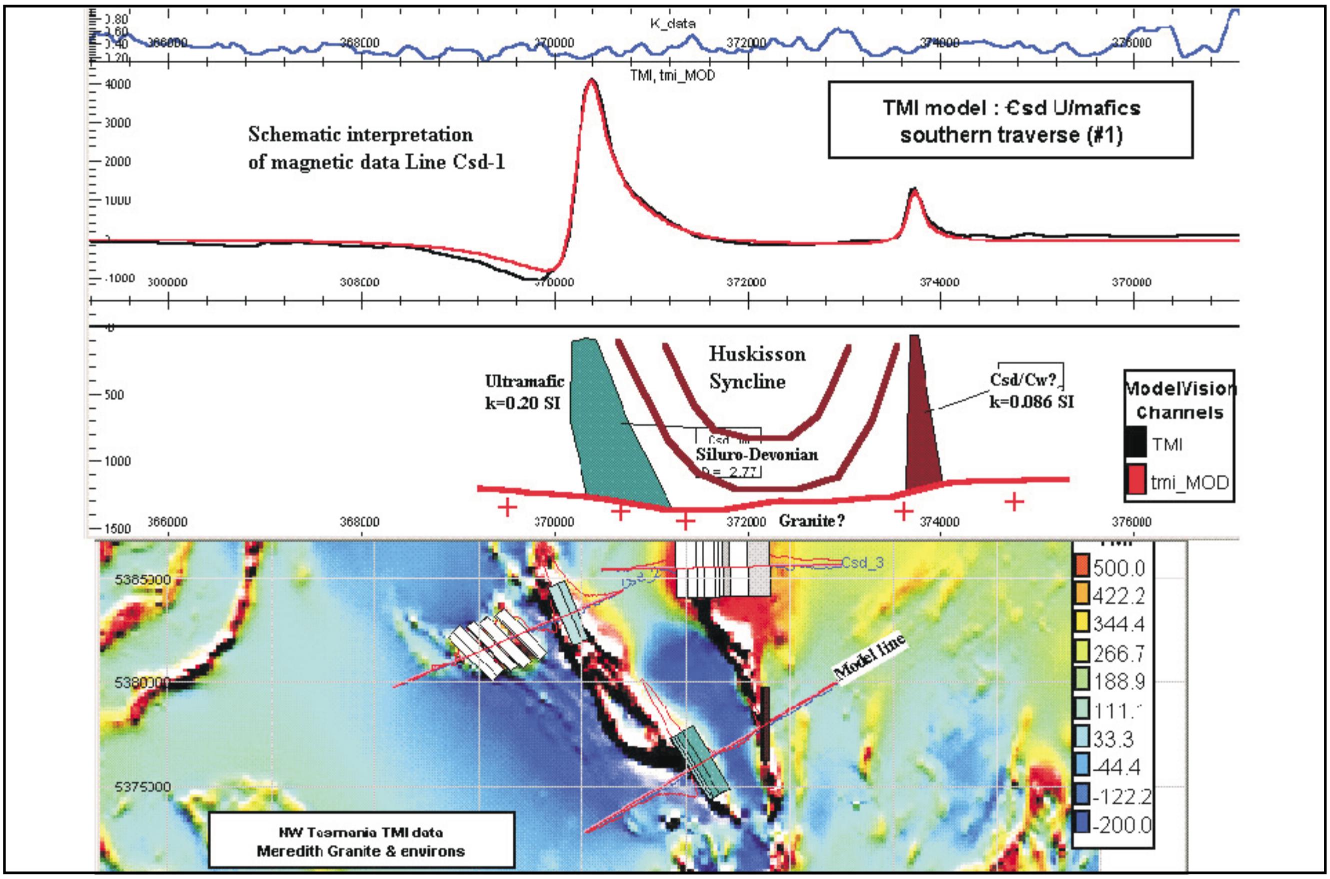


Figure 80

TMI data and model of traverse Csd_1

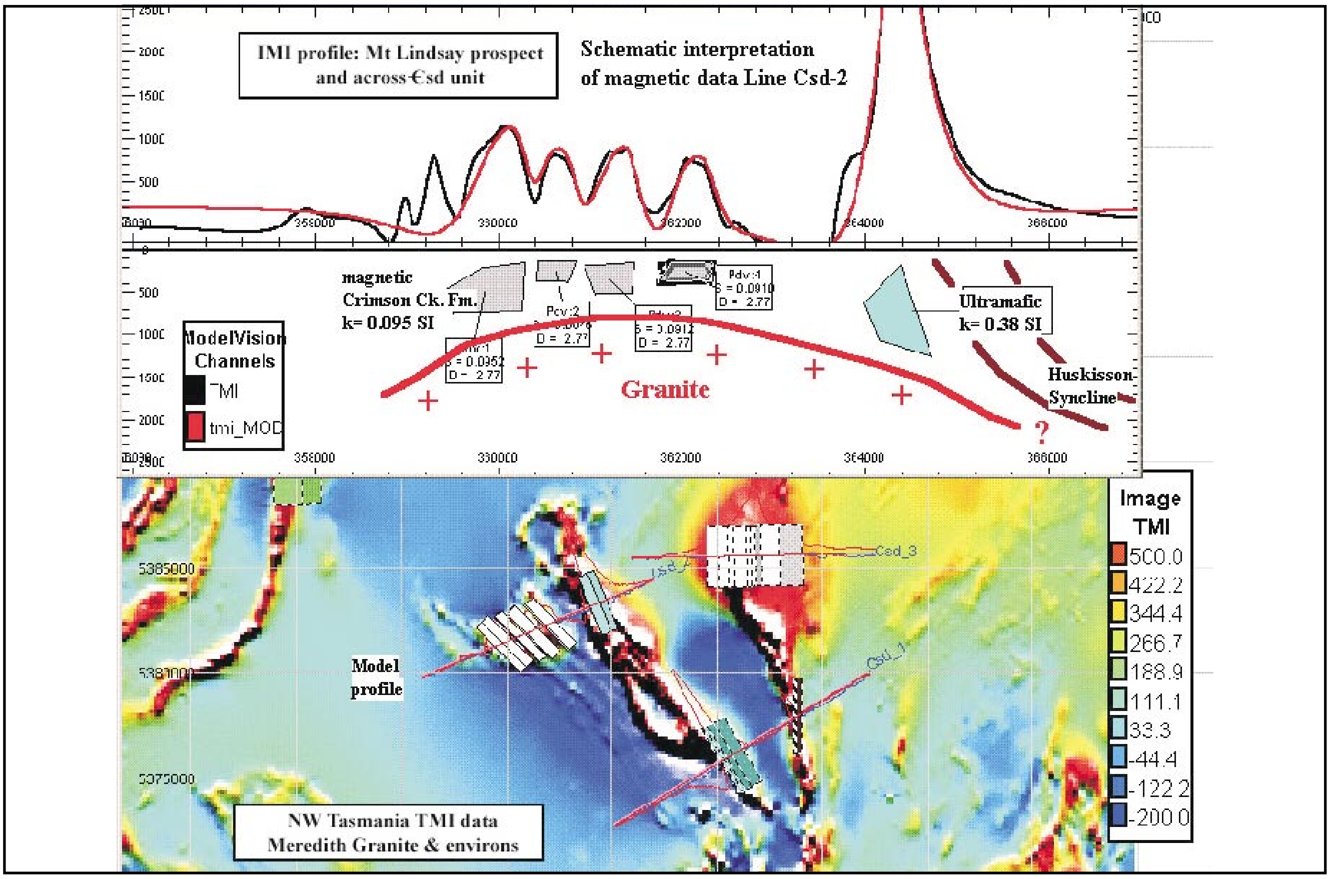


Figure 81

TMI data and model of traverse Csd_2

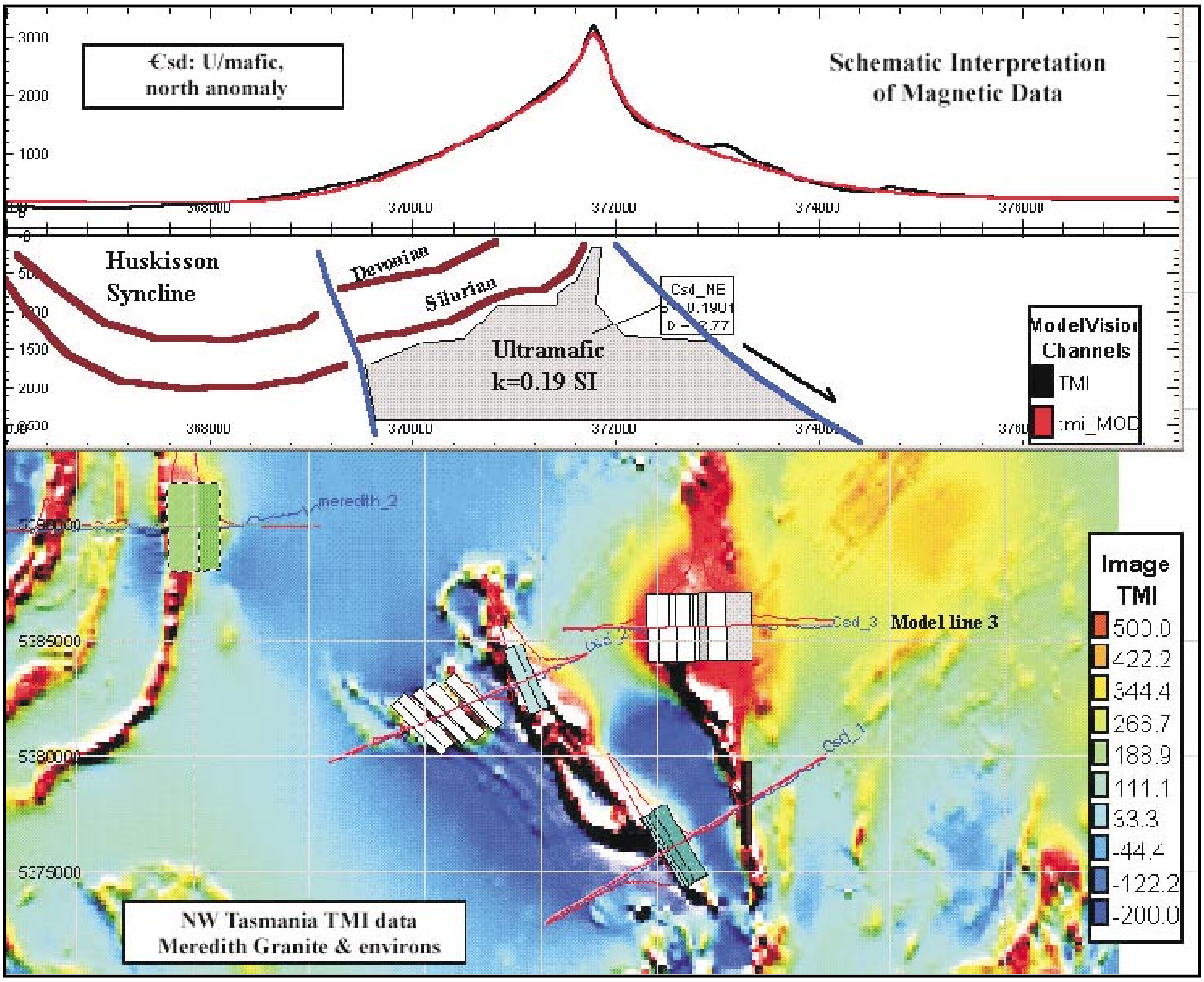


Figure 82

TMI data and model of traverse Csd 3

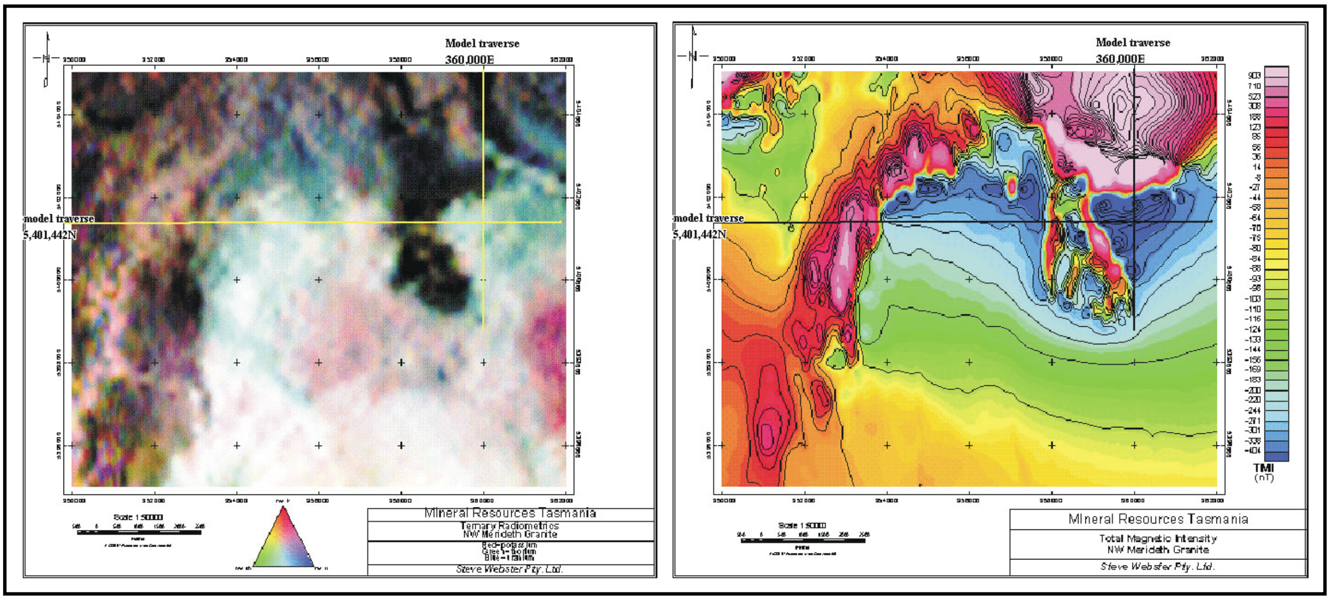


Figure 83

Radiometric and magnetic data, NW Meredith Granite, showing model traverse lines

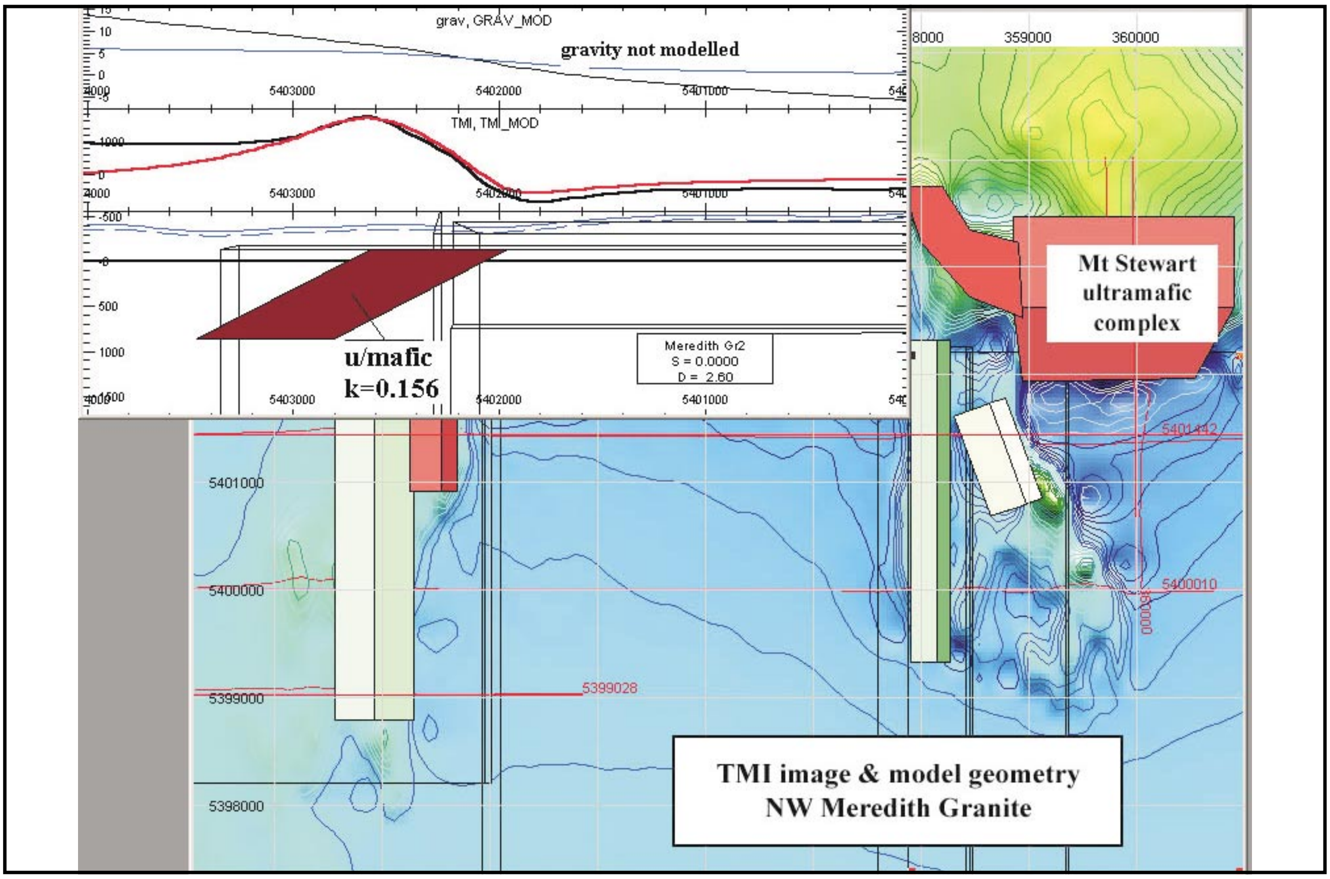


Figure 84
Model of N–S traverse along 360 000 mE

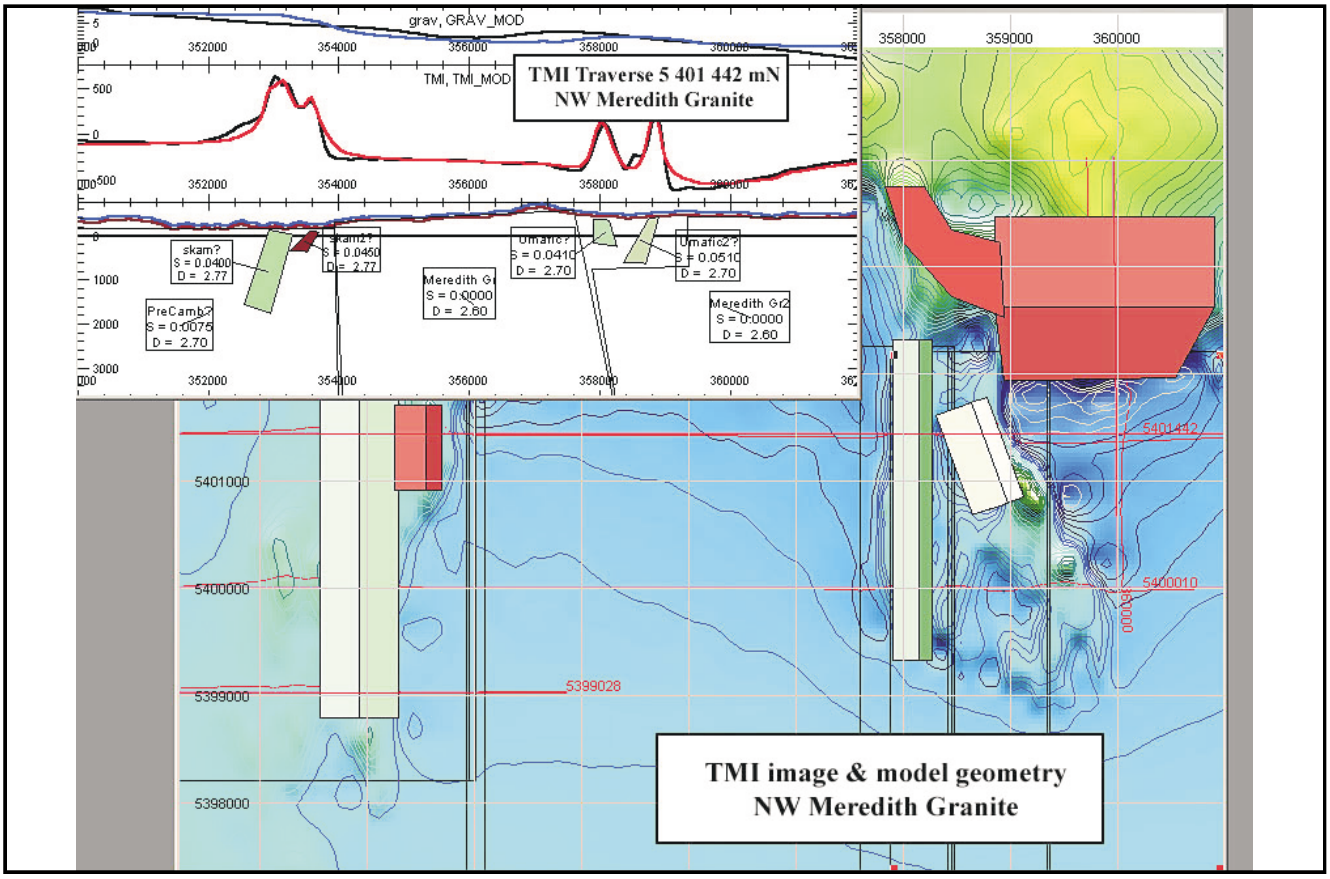


Figure 85
Model of TMI traverse along 5 401 442 mN

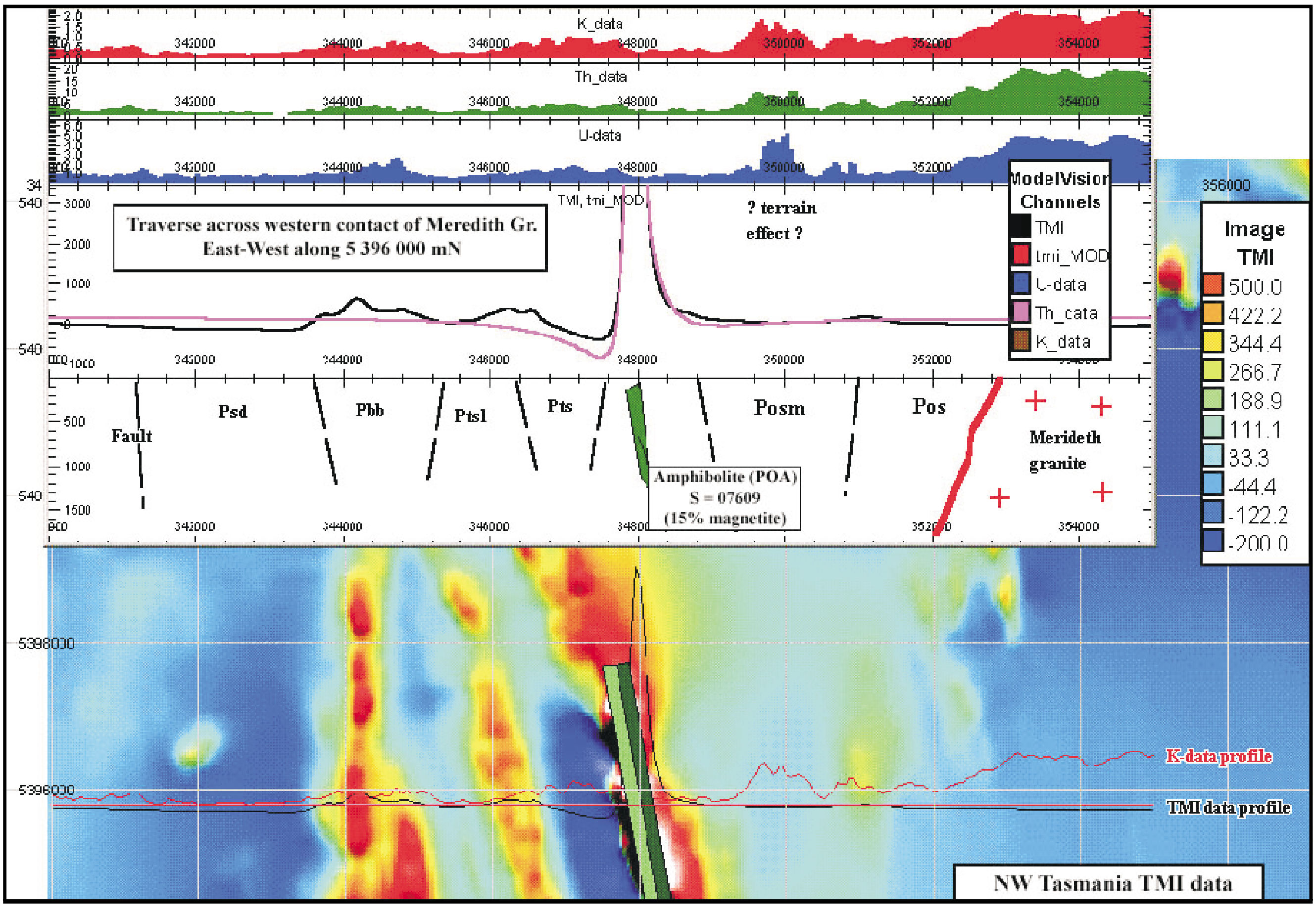


Figure 86

TMI profile across units of the Arthur Lineament

Renison and Meredith Block

The Renison tine mine was the world's largest example of a massive sulphide tin deposit and is located in a critical area for the understanding of regional structural features.

The study area is immediately to the south of the Australian Geological Survey Organisation (AGSO, now Geoscience Australia) seismic line 95AGS-T1, which has high priority for modelling verification of interpretation.

The aims of this study included:

(1) Checking of the AGSO seismic line interpretation.

(2) Modelling of two Berry sections (5 363 000 mN and 5 374 000 mN)

(3) Resolution of the Pine Hill granite aureole and Renison geology.

AGSO seismic line 95AGS-T1

The AGSO seismic line was sited along available road access to define deep crustal geology from the Arthur Lineament, across Neoproterozoic units, the Cambrian mafic-ultramafic complex and the Dundas Trough to the Henty Fault Zone.

Although data recording problems resulted in a final product that was not of the highest quality, an interpreted section (fig. 87) has been produced by AGSO that shows shallowly east-dipping extensional thrusts to be the main structural regime.

The interpreted section has been used as a base for modelling of the available gravity and magnetic data to ascertain if these data complement the AGSO result. As the modelling software would not support the actual meanders of the AGSO line, an east–west profile along 5 380 000 mN was used to simulate the position of the seismic line. Figure 88 shows the model results at two magnetic amplitude (vertical) scales to allow for both the large amplitude anomalies caused by ultramafic units and the subtle features of the metasedimentary rocks.

The dominant features of the magnetic data are the two anomalies (1000 nT and 4000 nT) related to the ultramafic units that flank the Huskisson Syncline. The models used are the same as used to simulate these units as discussed elsewhere in this report. The models do not fit exactly with the AGSO section in dip and depth extent; this may be due to the effects of remanence that have not been incorporated into the physical properties.

The easterly dip of the basement and Neoproterozoic units is compatible with the gravity data that has a gradual gradient decrease in this direction. It is debatable whether the seismic feature is the Arthur Lineament, as there are no indications of the magnetic anomalies that are normally associated with the Arthur Lineament. The seismic feature is "an east-dipping thrust fault which defines the structural base of the Oonah Formation block to the east of the Arthur Lineament" (D. Seymour, pers. comm.).

The Cambrian metasediment units located in the centre of the line can explain the observed gravity variations, although these are minor and there is little magnetic grain to be used to support the interpretation.

The main feature in the east is the continued gravity gradient that requires the Granite Tor granite to extend, at depth, under the Mt Read Volcanics, to the Henty Fault. The mafic rocks of the Mt Read Volcanics can be used to explain the shallow magnetic anomalies in this vicinity and are in accord with the limited depth extent for these units.

In summary, the interpretation of features in the magnetic and gravity data on this line is not in contradiction with the AGSO interpretation of the seismic data which would require major modification of the result.

Regional cross-sections

Berry (1997) constructed several structural cross-sections (located on Figure 89) of the Dundas Trough and these were checked by modelling of gravity and magnetic data (Berry and Roach, 1997). This modelling used available (TASGRAV) gravity data and it was proposed to use the best available magnetic data. Problems in data levelling necessitated the use of older 1981 MRT magnetic data that had been upward continued to 1000 m level. The effect of the upward continuation solved some of the levelling problems integral in the old data, but it also had the effect of attenuating the responses of shallow geology. The current study was designed to use the latest MRT magnetic data to include responses from the shallow geology. The physical properties used by Berry and Roach (1997) have been slightly modified for this exercise and are shown in Table 1.

As with the traverse across the seismic line, this profile (fig. 90, note that geological symbols are as used by Berry and Roach, 1997) extends from the regional gravity high in the west to the gravity low of Granite Tor in the east. The centre of the profile crosses part of the ENE-trending gravity low, which implies that a granite ridge underlies the Cambrian volcanic rocks in this vicinity. Berry and Roach have interpreted in their model that granite underlies the whole section, with the depth to granite being deeper in the west (~4000 m deep) under the Crimson Creek Formation (Pdv). The granite is shallow over the rest of the section, except for where the Central Volcanic Complex (CVC) is modelled to be more than 3000 m thick.

The strongest anomalies (several thousand nT) in the magnetic profile are, again, those due to ultramafic units that flank the Huskisson Syncline. The Berry and Roach model requires that the ultramafic units merge in the south of the syncline and actually continue under the structure. This model may work with the upward continued data, however the implications from the low-level data are that these units do not continue under the syncline, as is concluded in modelling of the seismic line.

The magnetic data over the CVC on the line of the profile are not strongly anomalous. Inspection of Figure 89 shows that the line crosses at least three anomalous trends at relatively low zones and these units would otherwise have been of significance in the modelling. In the east, between the Henty Fault and Granite Tor, several significant magnetic anomalies are due to altered Murchison Volcanics and Cambrian granite.

Overall, the modelling is in agreement with the Berry and Roach (1997) revised section that significantly altered the original by including extensive granite and reducing the depth extent of the Central Volcanic Complex. The extent of the CVC has been further reduced in this study and replaced by granite.

The Berry section to the south, along 5 363 000 mN, was not modelled as the line would be located along the southern edge of the ENE-trending gravity low/granite ridge. The modelling was deemed to be not practical nor meaningful.

Relationship to mineralisation

A significant feature of the Devonian Meredith Granite is the geophysical reflection of a metamorphic aureole that extends up to 2.5 km into the country rock. This aureole contains hornfels of albite-epidote, hornblende and pyroxene facies (Groves *et al.*, 1973).

Typical geophysical responses are illustrated in Figures 91 and 92 where magnetic and radiometric patterns of lithology are distinctly altered within this zone. These responses were not observed in earlier data sets of lesser quality.

Figure 91 is located at the southeast edge of the granite, where northwest-trending Crimson Creek Formation (Pdv) and units of the Huskisson Syncline abut the granite. The units of the Pdv are 'volcaniclastic wacke, siltstone-mudstone with numerous basalt lava horizons' and they generally exhibit weak magnetic response. However within the aureole the magnetic anomalies of the Pdv are significantly enhanced. This zone hosts the Mt Lindsay skarn-tin deposit and rock samples from the vicinity have been measured (D. Clark, pers. comm.) for magnetic properties (Table 3). These data indicate a very high remanent component of magnetism in the Crimson Creek Formation units and skarn.

The radiometric response of unit Pdv is nondescript, except in the aureole which shows an above normal uranium channel response. As the skarn deposits are reported as 'fluorine rich magnetic skarn', it is assumed that the high fluorine content is associated with the higher uranium count. To the north, the units of the Huskisson Syncline show a higher magnetic grain than elsewhere in the syncline and an abrupt change in radiometric responses is also observed.

Figure 92 shows the geophysical data for the northeast area of the Meredith Granite, where the higher potassium count of the radiometric data indicates the presence of a different phase of the batholith. The Cambrian unit (Ꞓw: mafic volcaniclastic lithicwacke, siltstone and mudstone with minor carbonate and basalt) that flanks the granite shows higher apparent susceptibility than normal and this is assumed to represent effects related to the metamorphic aureole. Variable radiometric patterns are also observed within this zone.

Figure 93 shows the magnetic and radiometric data in the vicinity of Renison tin mine. In this area the Pdv units are located over the "ENE trending ridge of granitoid almost linking the Heemskirk and Granite Tor granites" (Leaman and Richardson, 1989). This ridge is evident from examination of the regional gravity data as a series of circular anomaly closures and interpretation indicates that the Devonian granite(s) is within one kilometre of the surface.

Granite has been intersected at depth beneath the mineralised rocks of the Renison mine (Williams *et al.*, 1989) and has been related to the Pine Hill stock (Patterson *et al.*, 1981). Webster (1984) proposed (from 1970's magnetic data) that the two kilometre diameter complex magnetic pattern reflects the metamorphic aureole of this granite stock. The new generation of magnetic and radiometric data for this area show complex patterns which support the model, as discussed below.

The complex magnetic aureole comprises several highs and lows (± 500 nT) with a 4000 nT anomaly at the southern limit of the zone. Several TMI profiles were interpolated from the grid to model selected aspects of the complex (fig. 94).

The strong southern anomaly (over Cambrian serpentinite [Ꞓsm] outcrop) was modelled (fig. 95) along a NE-trending traverse to show two parallel sources of strong apparent susceptibility (0.195 and 0.25 SI units). The stronger unit, being on the inner side of the aureole, may reflect a closer position to the proposed intrusive body.

The modelling has assumed that any vector component of remanence is orientated in the direction of the Earth's current magnetic field, as per the findings of Clark (1984). In that work, samples of various rock types and mineralisation in the vicinity of Renison were measured for magnetic properties. It was concluded that remanence was important to interpretation and that the main events were:

(1) Remagnetisation of the area, probably associated with granite emplacement during the Late Devonian, producing a component with mean declination of 020° and inclination of -21° which is preserved by magnetic grains with higher blocking temperatures in the ultramafic rocks.

(2) Overprinting by a pervasive low-grade thermal event that is inferred to be associated with the major Jurassic dolerite sill emplacement with steep negative inclinations.

Traverse 2 (fig. 96) is located across the centre of the complex with a NW–SE orientation and essentially crosses units of the Crimson Creek Formation (Pdv).

The magnetic profile shows a series of positive and negative anomalies of equal amplitude that have been modelled as follows:

(a) Units of normal magnetism (Io = -72°and Do = 014°) from shallow depth to 600 m below surface. These units have an apparent susceptibility of 0.08 SI and are noted as Pdv in Figure 96.

(b) The negative anomalies are modelled by two blocks at depths from 500 m to 1000 m with reversed magnetic remanence (Q = 2, indicating twice the apparent susceptibility) and assumed opposite polarity (nominally Io = 90° and Do = 180° as this vector is unknown).

As the interpreted depth extent of the remanent magnetic blocks is of the same order as the noted depth to granite(?), it is interpreted that the negative vector is induced by a late phase of the intrusive (negative remanence is common in Early–Mid Carboniferous intrusive rocks). Thus the presence of the negative anomalies within such a magnetic complex may be used in exploration as an indicator of mineralisation.

This model has been checked by analysis of an additional profile (fig. 97) in the north of the complex. This traverse is orientated E–W and passes over Dreadnought Hill and Colebrook Hill, near the Renison mine.

The ultramafic unit (Ɛsps) on the flank of Colebrook Hill is modelled by a thin body of strong susceptibility (0.219 SI). If remanence is present it is sub-parallel to the Earth's current field, as discussed above.

The positive anomalies in the west of the traverse correlate with Pdv outcrop and no remanence component is necessary to model these features. The broad magnetic lows in the centre of the line must be due to a deep source with a negative remanent vector. This is interpreted to represent a contact metamorphic effect, in the depth range of 700–1000 m below surface, related to the granite proposed in this position.

Conclusions

(a) The broad metamorphic aureole around the Meredith Granite has a significant magnetic and radiometric expression that may be useful in exploration to indicate the presence of buried intrusive rocks. Such a pattern is observed as an extensive anomaly complex at Renison, and to a lesser extent at the Mt Lindsay, Cleveland, Zeehan and Mt Bischoff tin mines.

(b) At Renison, the positive magnetic anomalies of the complex are in agreement with the findings of Clark (1984) that the shallow Pdv units are enhanced by remanence that is sub-parallel to the Earth's magnetic field. This is consistent with a Late Devonian palaeodirection. The negative anomalies are proposed to be related to metamorphic effects of a later intrusive phase (Early–Mid Carboniferous?) that has reset the magnetism with opposite polarity. Verification of this interpretation would require measurement of samples from deep within the Renison tin mine.

Strong negative magnetic anomalies are observed to the south of the Heemskirk Granite within a complex related to ultramafic rock units. This zone should be investigated for potential mineralisation.

(c) Modelling of the regional sections showed the benefit of checking the extrapolated geology with magnetic and gravity data, as the latter can place constraints on the position and extent of some lithologies at depth. In the example of the three geological sections modelled in this study, the main change was in the amount of granite that is required to explain gravity features. Although the presence of some granite can be inferred from alteration effects observed in surface geology, the actual amount required is unexpected, yet has significant implications for further mineral exploration.

Table 1

Physical properties used in modelling

Unit	*Symbol*	*k (SI)*	*Density (t/m³)*	*Range*
Tertiary sedimentary rocks	Tert			
Tertiary basalt	Tb	0.065	2.77	
Eldon Group	Dvs	0.0013	2.69	
Owen Comglomerate	Gl		2.73	2.73–2.81
Other Denison cycle	DC	0.004	2.68	
Tyndall Group	Ty	0.013	2.69	
Central Volcanic Complex	CVC	0.005	2.69	2.70+
Que–Hellyer Volcanics	QHv	0.0013	2.72	
Altered Murchison Volcanics	aMV	0.04	2.68	
Eastern quartz-phyric sequence	EQ	0.013	2.68	
Farrell Slate	FS	0.0013	2.67	
Sterling Valley andesites	SA	0.0013	2.71	
Huskisson Group	HG	0.005	2.68	
Sticht Range Formation	SRF	0.0013	2.66	
Crimson Creek Formation	CCk	0.0065	2.71	
Precambrian basement	PC	0.00013	2.69	
Devonian granite	DGr	0	2.6	
Cambrian granite	CGr	0.04	2.68	
Serpentinite	Sp	0.13	2.68	
MUC basalt	bas	0.04	2.68	

Modified after Berry and Roach, 1997

Table 2

Magnetic properties in vicinity of Renison tin mine

Sample #	*#*	*Rock type*	*Location*	*k (ave) ucgs*	*Q (ave)*	*NRM Decln*	*NRM Incln*
RE01 A-B	2	Quartz porphyry	Dalcoath open cut	3.5	0.66	83	-56
RE01 C	1	Hornfels	Dalcoath open cut	240	49	257	-22
RE02 A-D	4	Gabbro		165	28.3	227	-18
RE03 A	1	Crimson Creek Formation	Pine Hill Road	37	0.04	185	-76
RE04 A	1	Weathered ultramafic rock		36	0.13	136	19
RE05 A-B	2	Dundas sediment	Dundas tramway	20	0.03	335	-74
RE06 A-B	2	Spilite	Dundas tramway	47	0.85	342	-48
RE07 A-C	3	Ultramafic	Side track from tramway	6530	4.6	26	-24
RE08 A-D	4	Spilite	Dundas tramway	52	0.1	351	-62
RE09 A-J	10	Serpentinised ultramafic	Open cut N of Melba Flats	3574	2.3	20	-21
RE10 A-E	5	#2 dolomite and ore	South Stebbins 2035	180 & 3550	1.3 & 1.7	360	-60
RE11 A	1	Dalcoath member	Howard 2035	1800	6.5	101	-61
RE11 B-C	2	#3 ore	Howard 2035	3260	2.1	228	-74
RE12 A-C	3	Federal ore	Federal 2000	11,600	5.6	190	-52
RE13 A-B	2	Melba ore	Melba 2015	7885	2.2	52	-70
RE13 C	1	Mineralised RBM	Melba 2015	2640	1.5	256	-82
RE14 A	1	Dolerite	R44	90	4.1	325	-81
RE14 B, D	2	Red Rock Member	R44	63	0.92	350	-77
RE14 C	1	Dolerite	R44	240	18	313	-83
RE14 E	1	Mineralised RRM	R44	7120	1.9	234	-67
RE15 A-D	4	#3 ore	S.A.2	6800	1	109	-36
RE16 A-B	2	Red Rock Member	300 m down from #2 adit	30	0.06	316	-72
RE16 C	1	#2 dolomite	300 m down from #2 adit	23	0.14	42	-77

Table 3
Magnetic properties in vicinity of Mt. Lindsay prospect

Site#	*Susceptibility (ucgs)*	*Susceptibility (SI)*	*Koenigsberger Ratio*	*Petrological Description*
1	9,450	0.1188	0.63	massive pyrrhotite and magnetite
2	430	0.0054	2.00	massive pyrrhotite
3	125	0.0016	0.15	massive pyrrhotite
4	330	0.0041	10.40	CCF (basaltic mudstone)
5	200	0.0025	197.00	CCF (cherty mudstone)
6	27,510	0.3458	2.47	weathered magnetite skarn
7	22,410	0.2817	8.50	skarn, after limey mudstone
8	7,500	0.0943	6.90	basaltic silty mudstone
9	9,270	0.1165	0.36	basaltic mudstone

*cgs = SI/(4*PI)   CCF: Crimson Creek Formation*

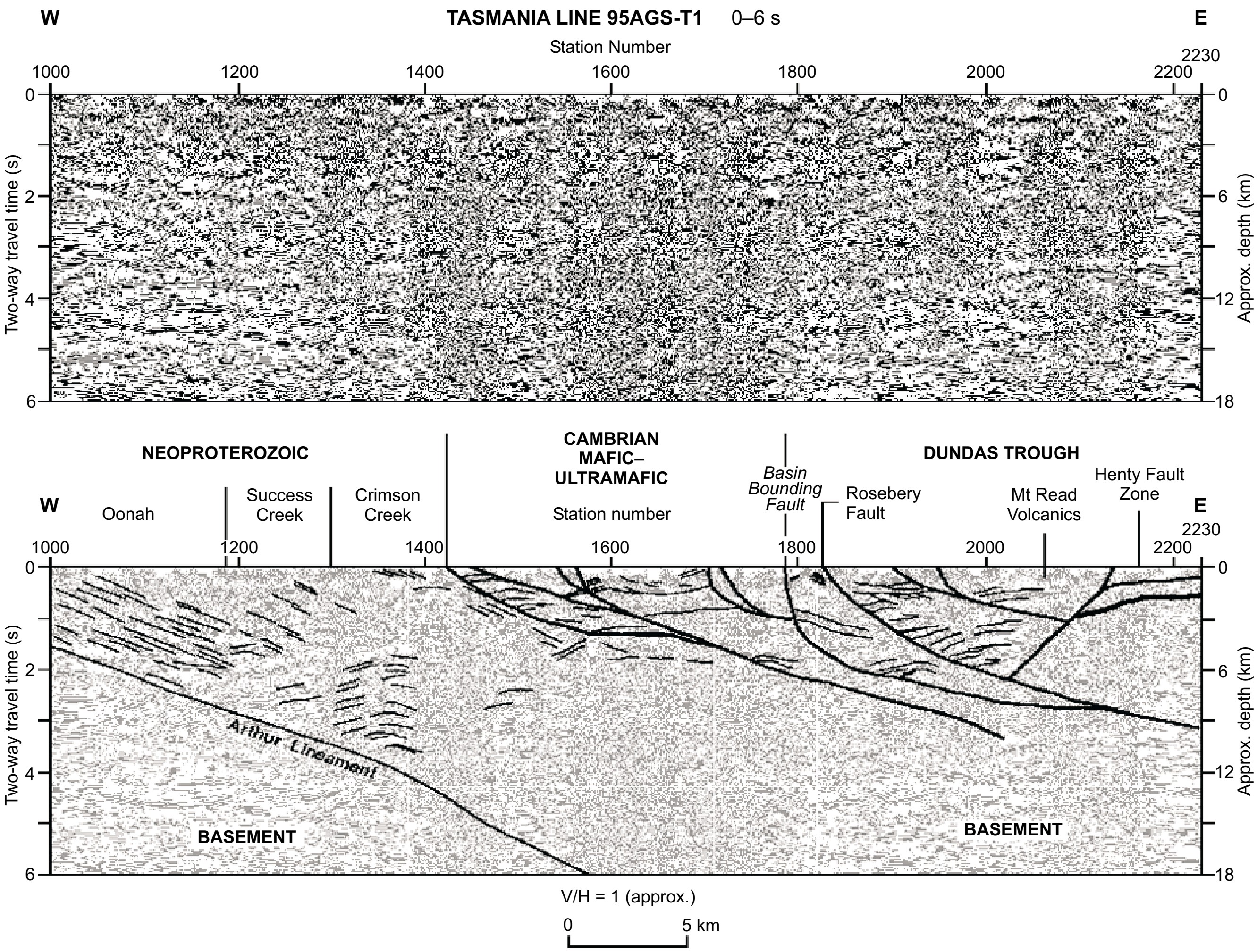


Figure 87
AGSO seismic line 95AGS-T1 and interpretation

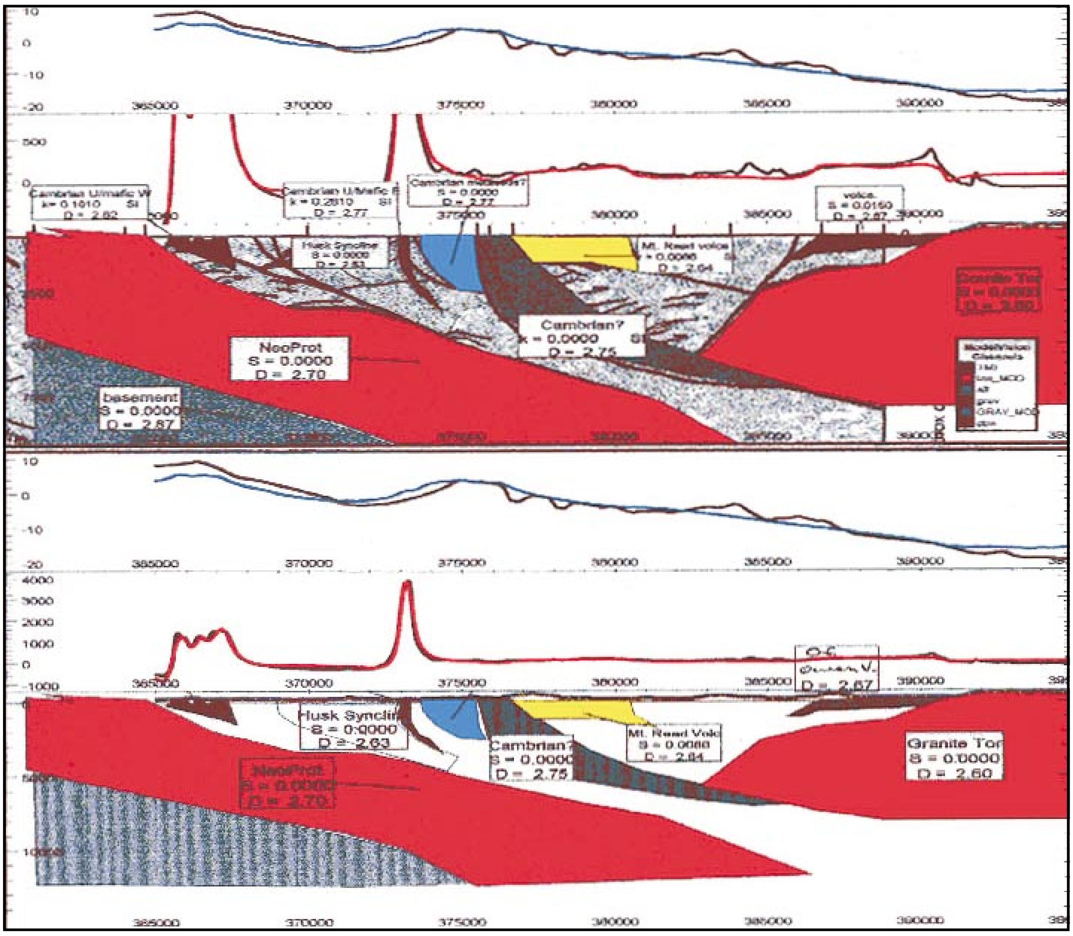


Figure 88
Modelling of TMI and gravity data for AGSO seismic line 95AGS_T1, NW Tasmania

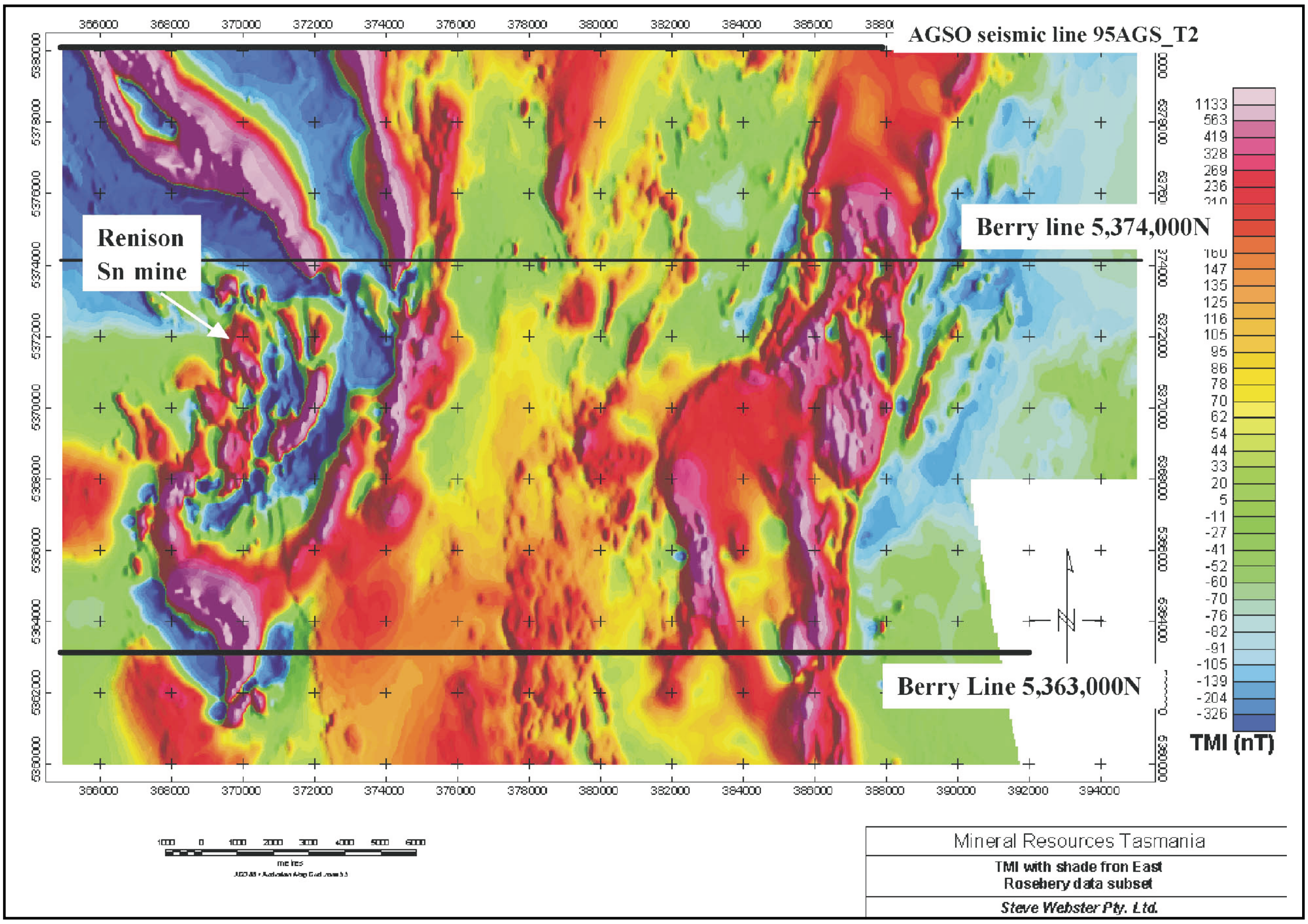


Figure 89

Location of seismic line and reconnaissance traverses

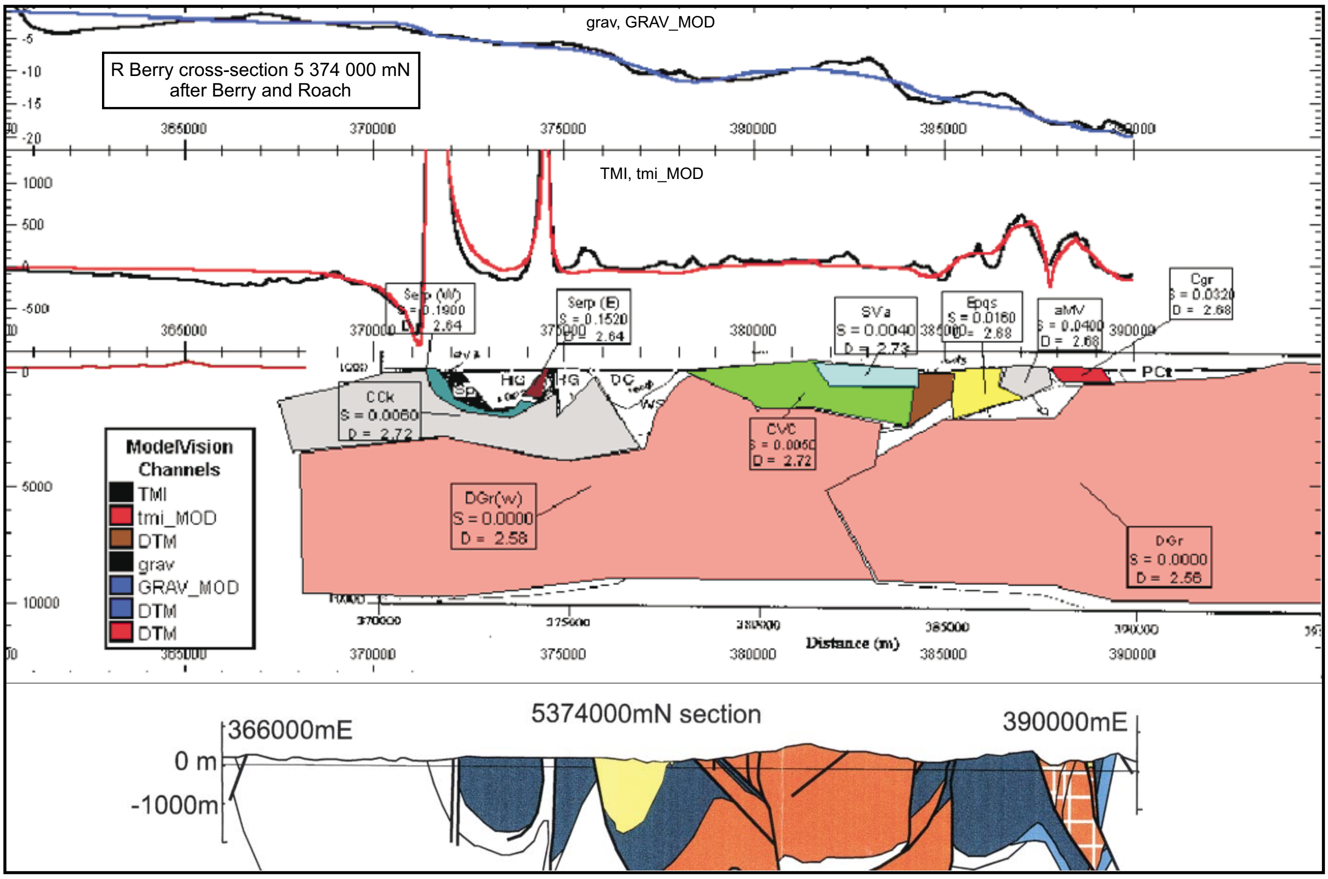


Figure 90

Gravity and magnetic model of geology section 5 374 000 mN (after Berry, 1997)

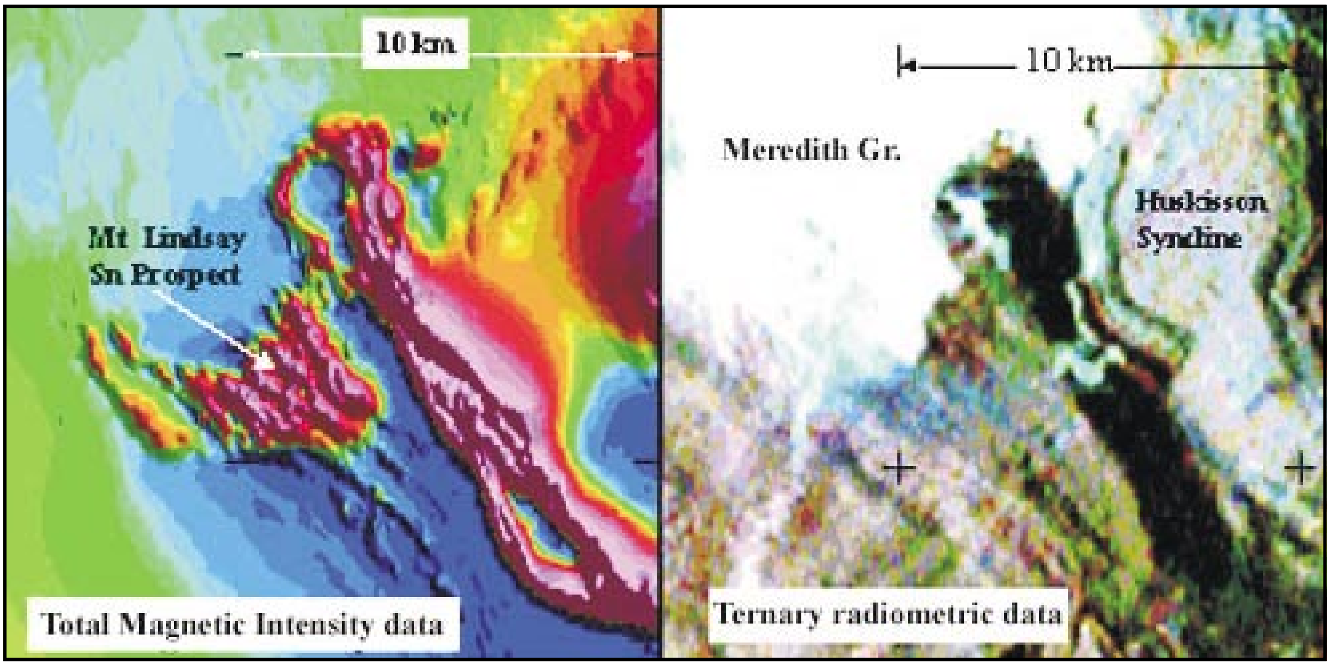


Figure 91

Magnetic and radiometric data for southeast part of the Meredith Granite contact and environs showing the magnetic and radiometric aureole extending two kilometres into country rock units

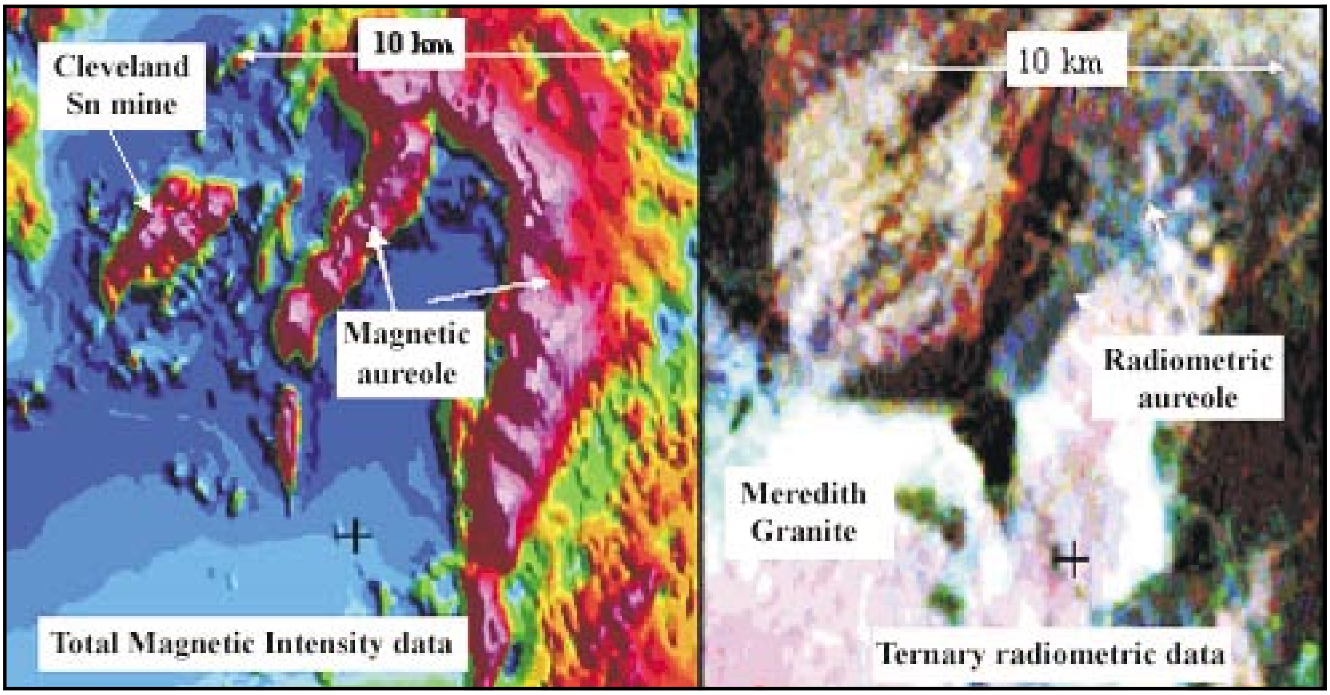


Figure 92

Magnetic and radiometric data for northeast part of the Meredith Granite contact and environs showing the magnetic and radiometric aureole extending two kilometres into country rock units

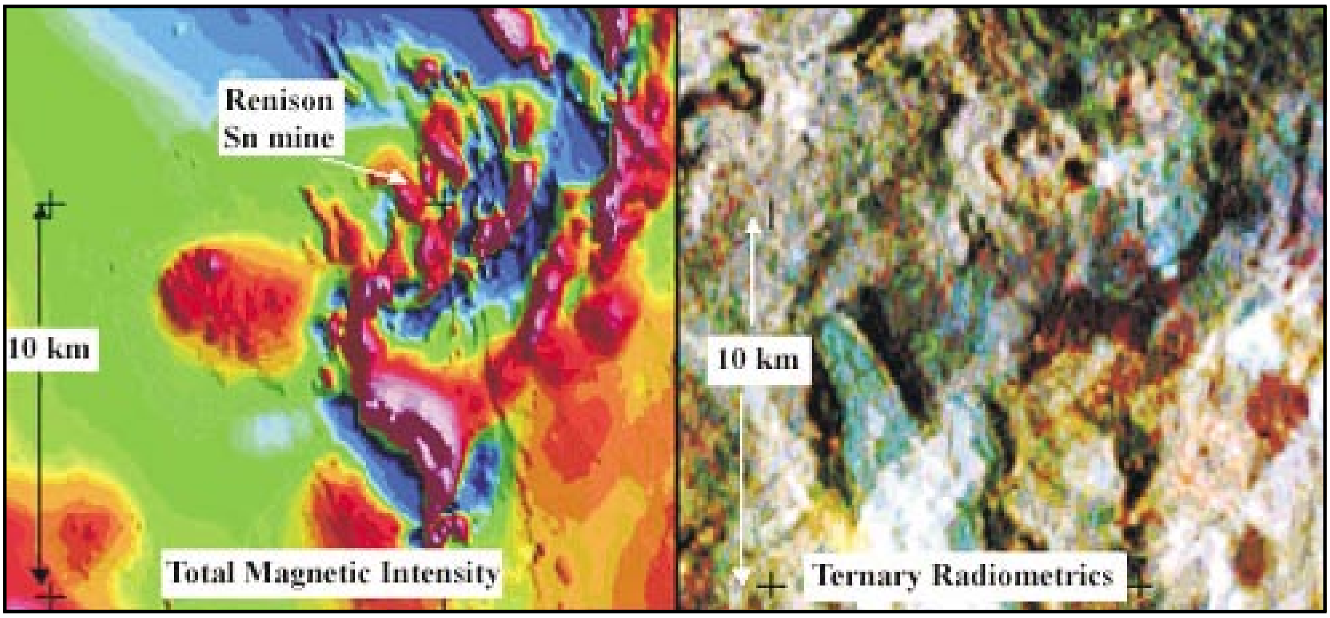


Figure 93

Magnetic and radiometric data in vicinity of Renison tin mine showing strong magnetic anomalies and complex radiometric pattern that is due to granite intrusion at a depth of one kilometre or less

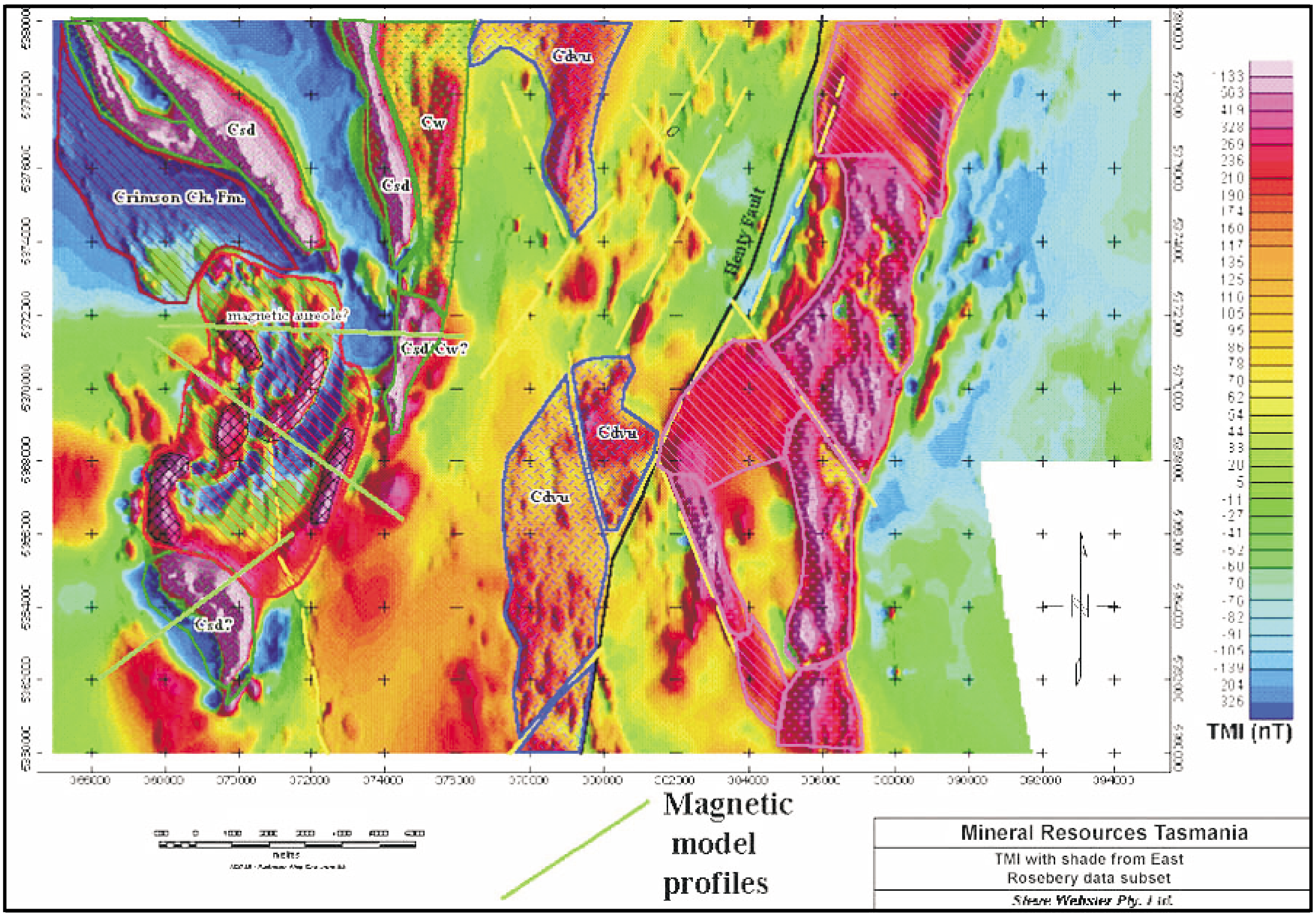


Figure 94

TMI interpretation and profile location in vicinity of Renison mine

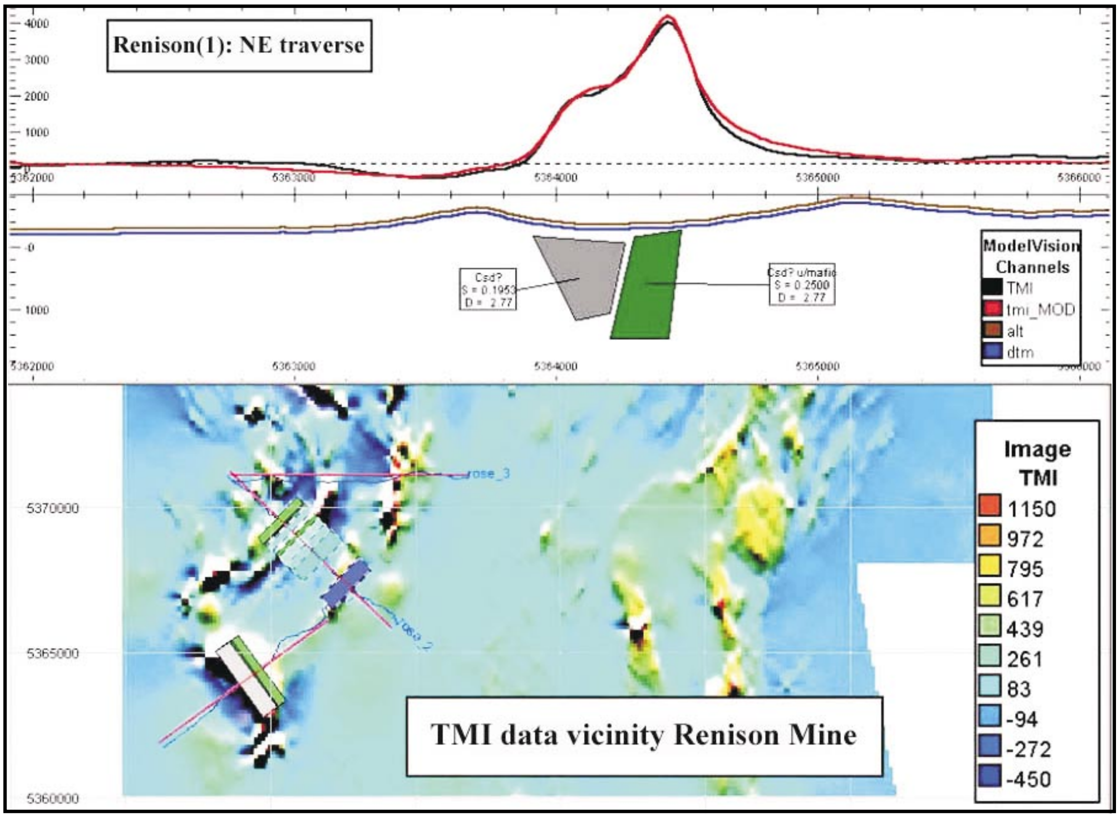


Figure 95

Magnetic model of NE – SW profile, Renison area

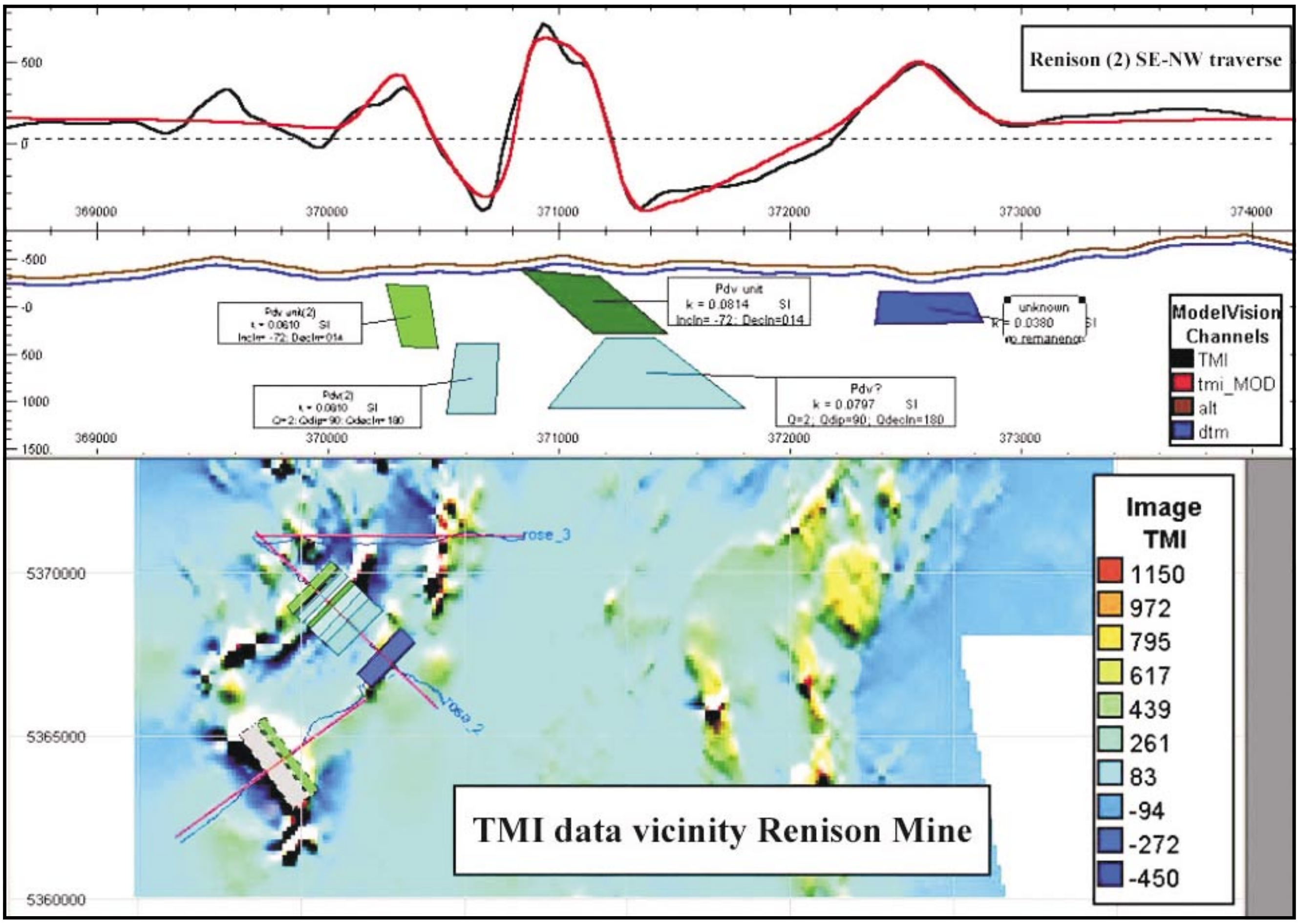


Figure 96
Magnetic model of NW–SE profile, Renison area

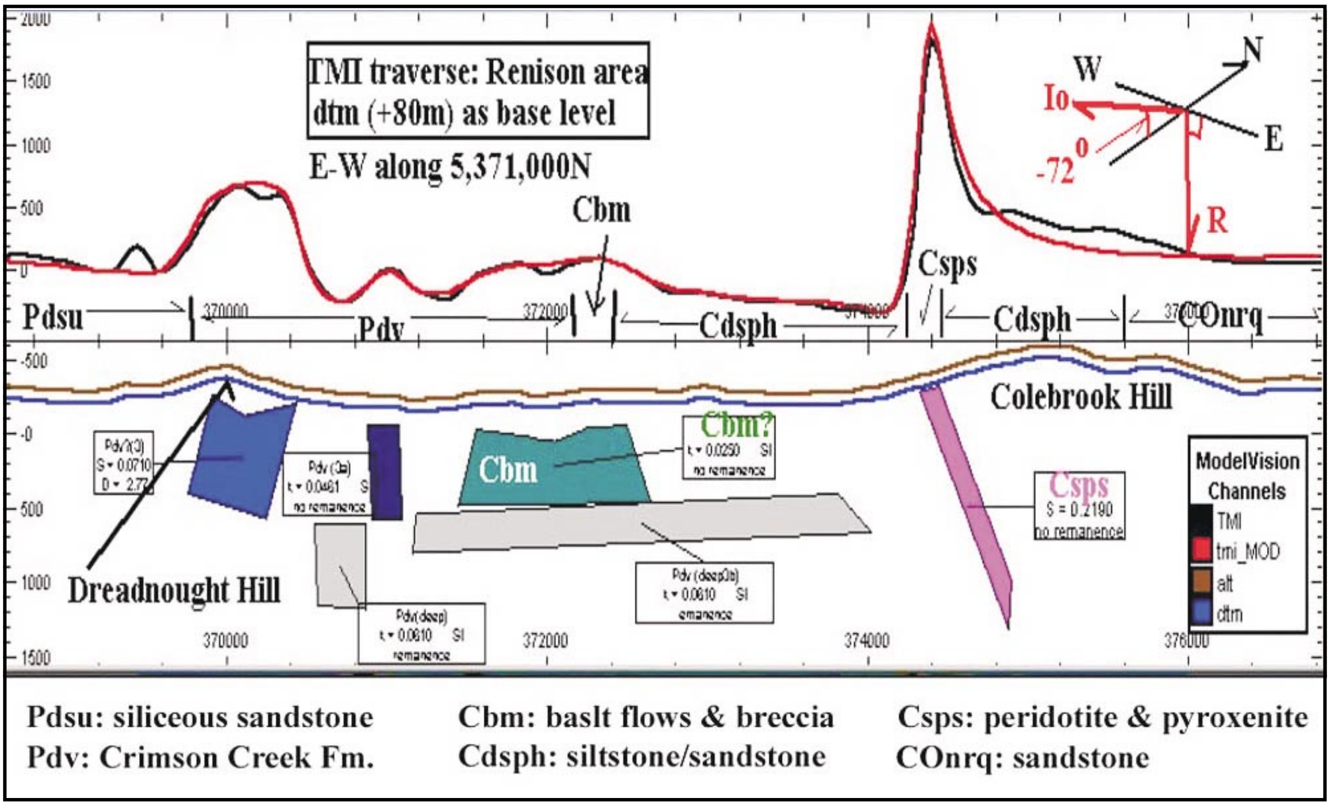


Figure 97
Magnetic model of E–W profile, Renison area

Heemskirk Granite–Zeehan

The aim of this study was to ascertain if the airborne geophysical data could assist in defining the geometry of the southern contact of the Heemskirk Granite. Figure 98 illustrates the published 1:25 000 scale geological map of this area (Trial sheet, McClenaghan, 2001)) and shows that the Devonian granite is in contact with the Precambrian Oonah Formation, with an approximate east-west orientation. The Oonah Formation is unconformably thrust over Cambrian sediments and the ultramafic rocks (Ꞓsd) are inferred to be thrust over younger Palaeozoic sedimentary rocks.

The Heemskirk Granite is interpreted from magnetic and gravity data to plunge to the east, at a shallow angle, under the Cambrian units as far as Zeehan (fig. 99). This area hosts abundant mineral localities and mines of historical significance, which contain diverse mineral types from gold, tin, silver-lead to nickel. Most of these deposits are either related to the granite or affected by its intrusion.

Current exploration activity, by Allegiance Mining NL, is focussed on the Avebury nickel prospect shown in Figure 99, which is located in a prominent east-trending magnetic anomaly. Figure 99 shows a subset of the airborne magnetic data acquired by MRT using 200 m line spacing with east-west orientation. The TMI data show the granite (mainly of S-type composition) to be essentially non-magnetic, although there are some phases (of I-type composition) that exhibit a weak magnetic grain. The plunge to the east is reflected by strong magnetic anomalies which are interpreted to be related to thermal alteration of mafic units and the generation of skarns in reactive units. These anomalies appear to deepen to the east, reflecting the attitude of the top of the granite. This interpretation is supported by gravity anomalies, although the gravity data spacing is not adequate to be incorporated into this detailed modelling study.

As noted above, the southern contact of the granite and the Oonah Formation trend east-west, as does the trend of the magnetic anomaly in the vicinity of the Avebury prospect. These features are thus not ideally resolved by the east-west flight line direction of the MRT airborne data set, even though the survey is of very high quality. In order to assist their exploration program, Allegiance Mining undertook an ultra high-resolution helicopter-borne magnetic survey utilising 50 m line spacing, with flight lines orientated north-south. This data set was made available to MRT for inclusion into this study; the TMI data are shown in Figure 100.

The TMI data for the heli-mag survey show the same anomaly features as seen in the MRT data set, although the anomalies are sharper and the image confirms the higher resolution. Figure 101 illustrates this point, by comparing a segment of the two data sets at the same scale. It is evident that the 200 m spaced east-west line (MRT data) produces a broader anomaly with a NE-SW trend bias for the magnetic grain. The 50 m spaced north-south line data produces a narrower anomaly with distinct east-west trend bias in the magnetic grain, although a NE-SW linear feature crossing the anomaly is still preserved.

Model Study

Four TMI profiles have been interpolated from the magnetic grid and compared with geological sections generated from the published geological map (fig. 98). The profiles were modelled to produce a fit to the magnetic data that was not in disagreement with the geological sections. The *ModelVision* software utilises 3D models with variable cross-sections to generate model profiles to agree with the input data. The same gross model geometry was used to simulate the ultramafic unit for three profiles, with smaller sources added to allow for variation along strike. The main ultramafic unit (Ꞓsd) has an apparent susceptibility of 0.1033 SI, with smaller units assigned a value of 0.0910 SI.

Traverse 350 000 mE

This traverse (fig. 102) crosses the main anomaly (2500 nT in relief) and two other minor features (each of 400 nT) that are assumed to relate to ultramafic units of limited strike extent that may be splays from the main intrusive body. Thus the anomaly profile comprises three peaks superimposed on a broad anomaly that requires a broad ultramafic body, almost one kilometre in width, with a northern edge that dips steeply towards the Heemskirk Granite.(fig. 102 has a V:H exaggeration of approximately 2:1).The model outcrop position is in agreement with the geological observation that 400–500 m of Cambrian sedimentary rocks and Oonah Formation exist between the granite and the ultramafic rocks. The trend of the anomalies related to the minor splay units fit with the observed trend of the ultramafic body to the southeast. The magnetic data cannot be utilised to provide any additional information about the attitude of the non-magnetic geological units.

Traverse 349 500 mE

This traverse (fig. 103) is located only 500 m to the west, yet the anomaly amplitude has increased to in excess of 7500 nT. To explain this anomaly change requires additional material with an apparent susceptibility of 0.38 SI, but contained within the original model body. As the mapped Heemskirk Granite is now less than 200 m from the model unit, it is interpreted that the extra magnetic material is the result of high temperature alteration to skarn-like material. Ironstone capping has been observed in geological mapping in the outcrop location of the model.

The nature of the modelling assumption is that the additional magnetic effects are due to remanence imposed from heating by the Devonian granite. Investigations in northwest Tasmania by the CSIRO (Clark, 1984) show that Devonian remanence directions are generally orientated closely with the Earth's current magnetic field, thus adding to induced anomaly amplitude. As remanence directions of the ultramafic units are unknown, it is reasonable to assume that the increased anomaly amplitude is due to the combined effects and can be simulated by increasing the apparent susceptibility of the ultramafic unit.

Traverse 349 000 mE

This traverse (fig. 104) is located 500 m to the west and the anomaly amplitude has decreased to 3000 nT, thus the amount of additional required material is less and only needs an apparent susceptibility of 0.08 SI. The model anomaly curve shape is not a perfect fit to the observed data and considerable model adjustment would be required to improve the comparison. As the overall curve match is adequate to model the relationship between the granite and the ultramafic unit, no further change has been made. The increased anomaly amplitude is again assumed to be due to high temperature alteration of the ultramafic unit as the granite is less than 200 m from the north face of the model.

Traverse 351 000 mE

This traverse (fig. 105) is located to the east of the other traverses, away from the bulk of the main magnetic anomaly and in a position where ultramafic rocks are not mapped in close proximity to the granite. The anomaly amplitude is reduced to 1500 nT and a separate body of ultramafic rocks has been generated to allow for a change in trend direction. The same two flanking bodies, as used in profile 350 000 mE, have been extended to cross this line.

The model geometry requires the ultramafic unit to virtually outcrop in order to fit the steep curve slopes and as it is located 600 m to the south of the granite, the apparent susceptibility is normal (0.11 SI). As the ultramafic unit is modelled to almost outcrop, it may be possible for detailed geological mapping to locate evidence for the unit to be verified.

The southern minor model unit at 5 355 300 mN does not have a good curve match, although the location is in agreement with the mapped outcrop of ultramafic rocks. Introduction of a different model body could be used to fit the curve shape, although this was not regarded as critical to the exercise.

Conclusions

The magnetic modelling was not able to determine the attitude of the southern margin of the Heemskirk Granite, although some limits were placed on the amount of Oonah Formation and Cambrian sedimentary rocks that could be present between the granite and ultramafic unit. The ultramafic unit was inferred, on all lines, to dip steeply north.

It was concluded that parts of the ultramafic unit were in close contact to the granite during emplacement and thermal alteration has imposed increased magnetic properties by resetting magnetism in a direction that parallels the Earth's current magnetic field. This has resulted in an apparent susceptibility that is up to five times its normal value and should be of use to focus exploration efforts.

Susceptibility sampling of the ultramafic unit would assist in revision of the models by placing limits into the analysis. Remanence studies would also be of assistance. Field mapping in selected localities may be able to verify the presence of the ultramafic unit in areas where it is currently unknown.

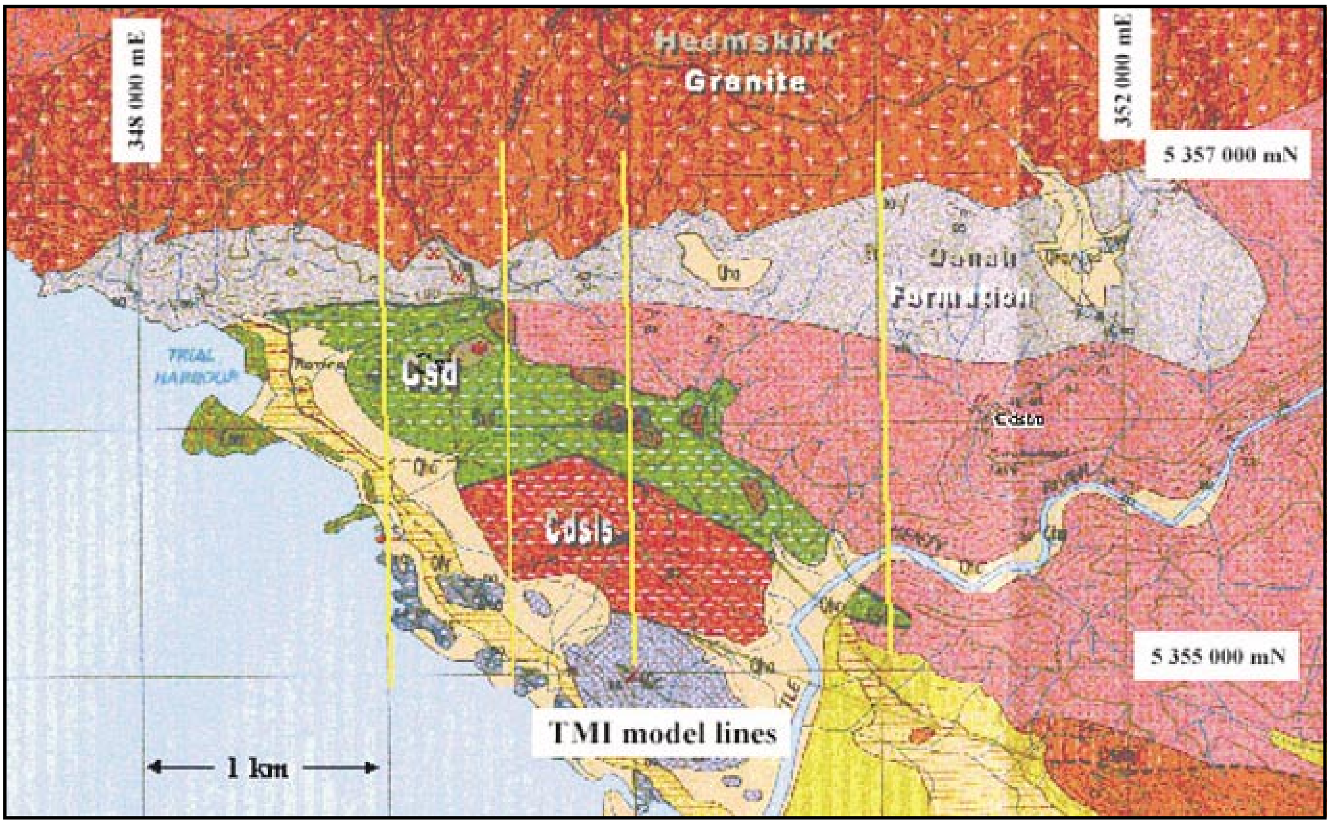


Figure 98

Part of TRIAL 1:25000 scale Geological Map showing model traverse lines

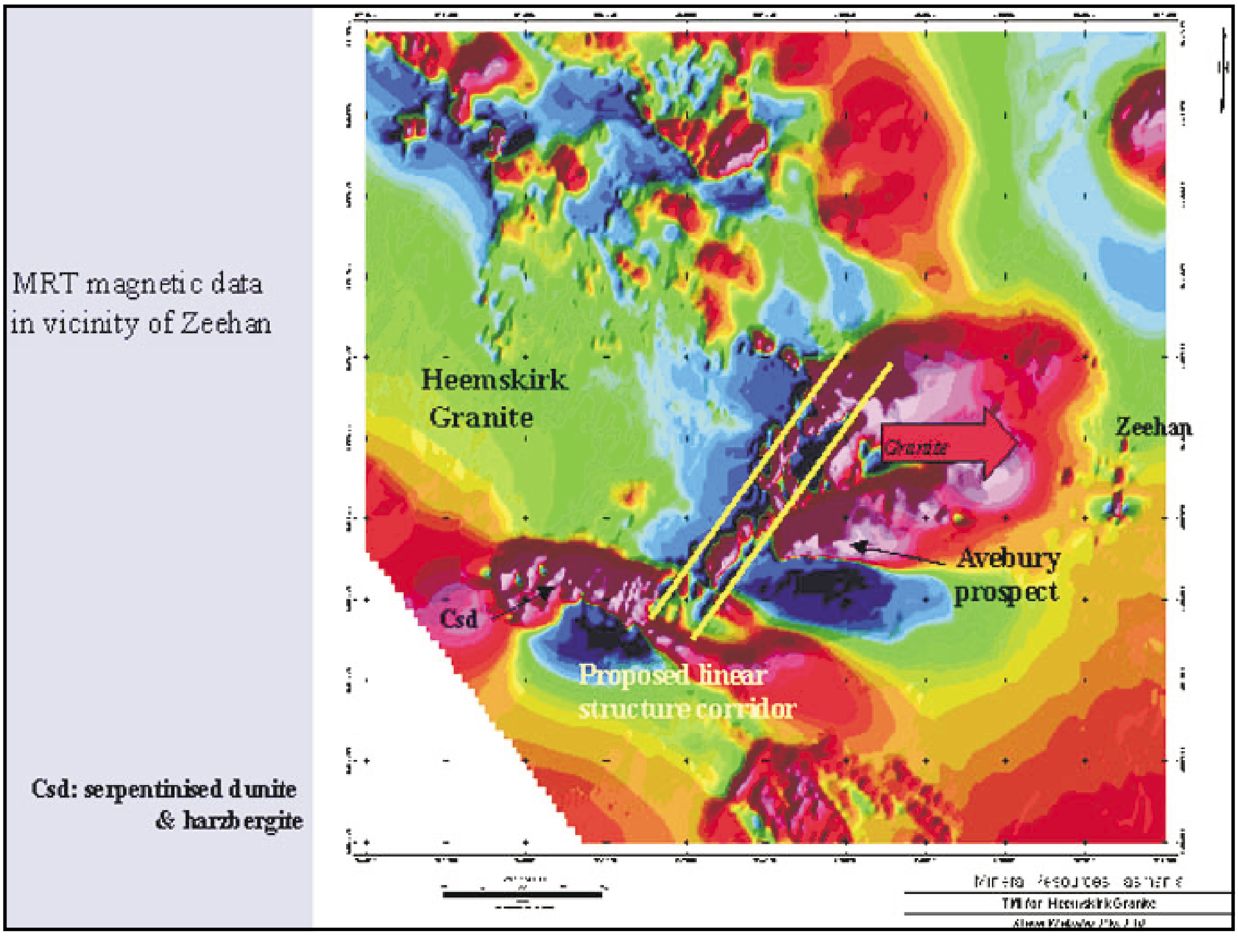


Figure 99

MRT magnetic data in vicinity of Zeehan

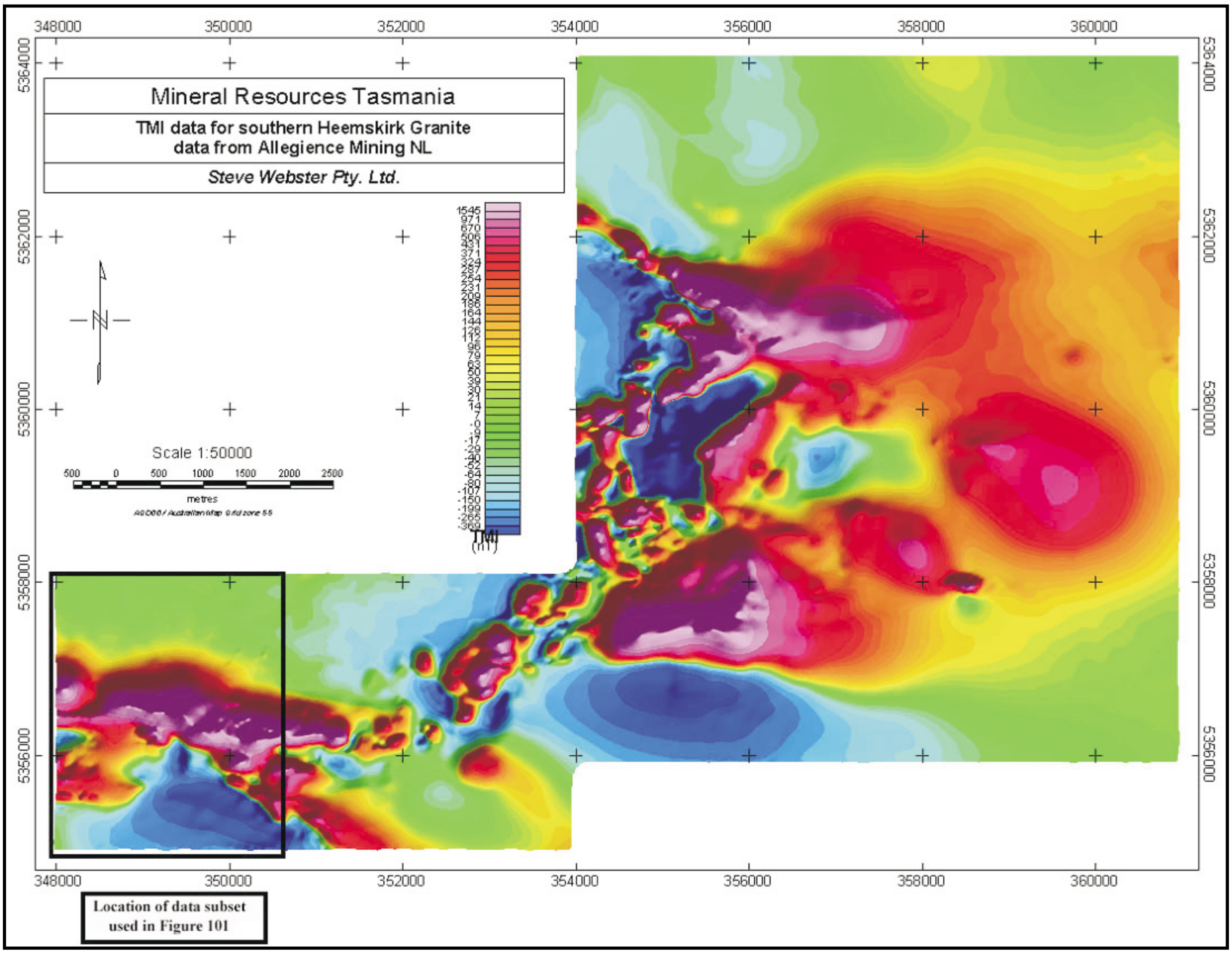


Figure 100
Allegiance Mining TMI data for southern Heemskirk granite.

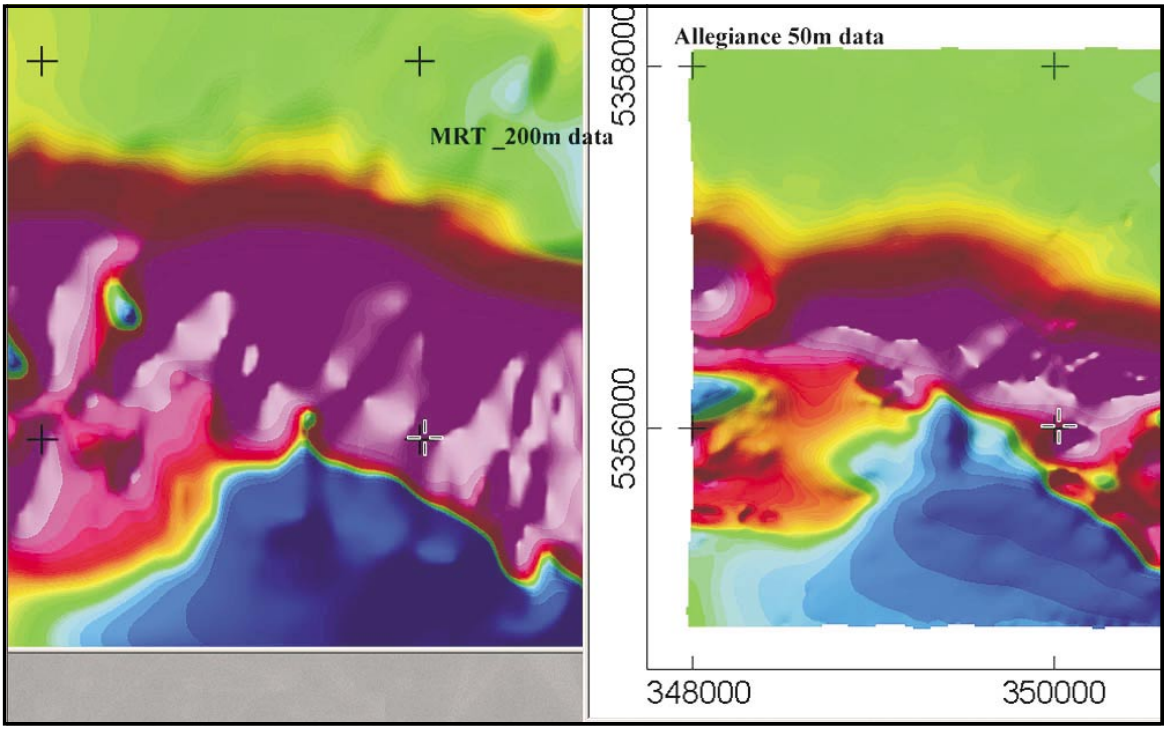


Figure 101
Comparison sample TMI image from MRT and Allegiance Mining data sets

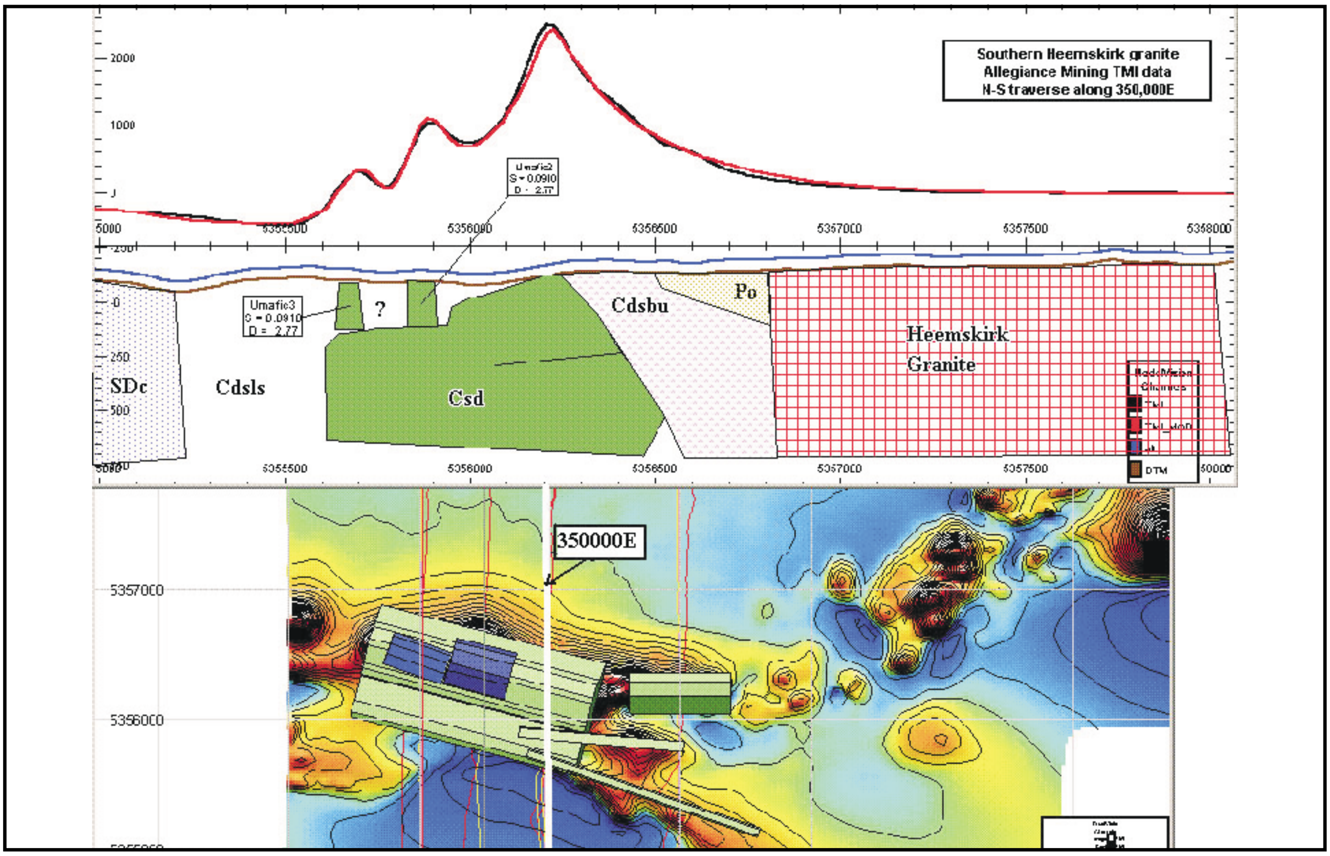


Figure 102

Model profile 350 000 mE and interpreted geological section.
Po = Oonah Formation, Csd = serpentinised dunite and harzburgite, Cds = Cambrian sediments

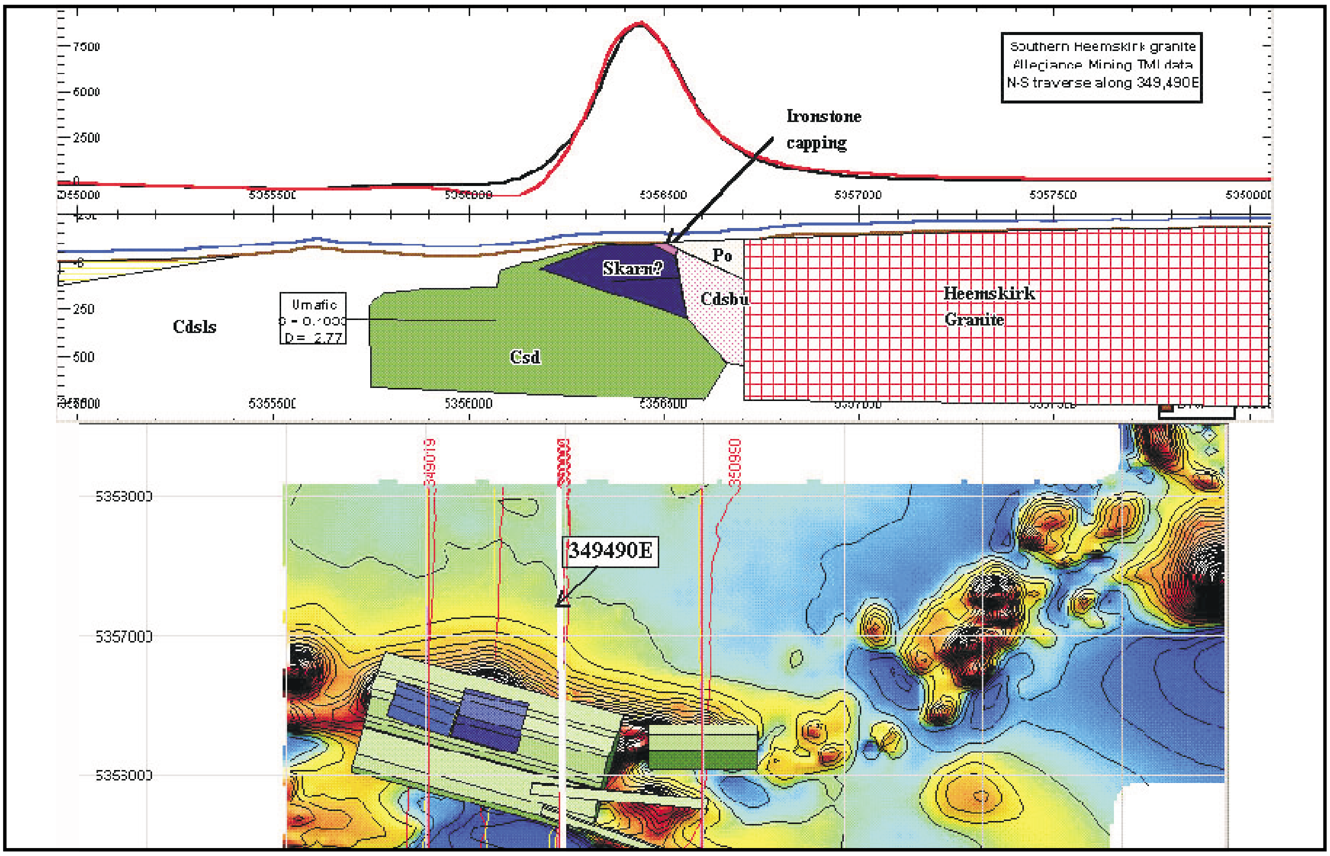


Figure 103

Model profile 349 500 mE and interpreted geological section.
Po = Oonah Formation, Csd = serpentinised dunite and harzburgite, Cds = Cambrian sediments

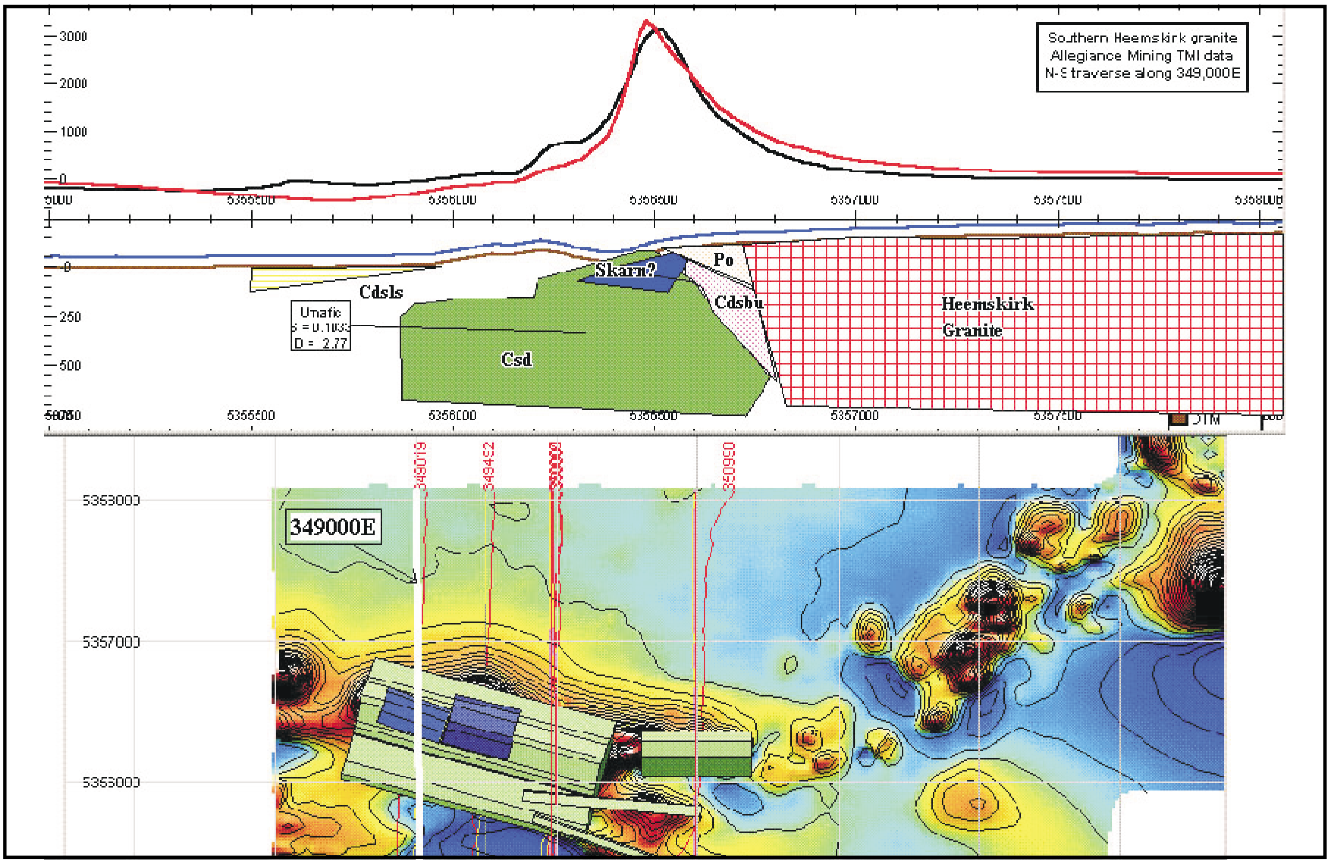


Figure 104

Model profile 349 000 mE and interpreted geological section
Po = Oonah Formation, Csd = serpentinised dunite and harzburgite, Cds = Cambrian sediments

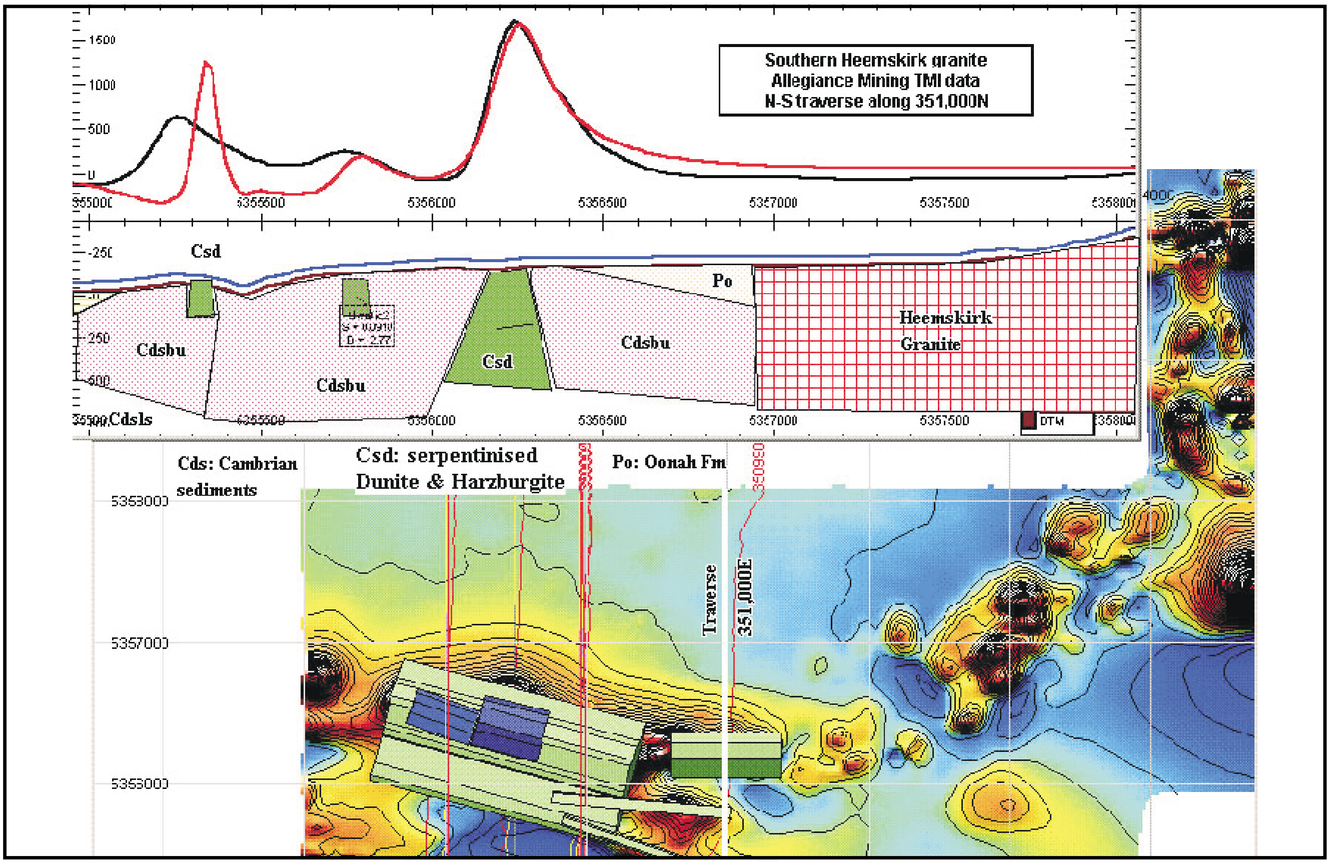


Figure 105

Data and model results for TMI traverse 351 000 mE

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