1. Introduction

The 2007 North Eastern Tasmanian airborne geophysical survey was designed to provide a high resolution data set, in combination with available regional gravity data, to facilitate a better understanding of the geology and exploration potential of this well mineralised area.

Interpretations of the earlier uncoordinated geophysical data sets tried to explain the association between mineralisation, gold in particular, and the host Ordovician – L. Devonian Mathinna Super Group units and M. Devonian granitoids. Roach (1994) pointed out the lack of physical property contrast between the Mathinna units and some granitoids, which precluded a unique solution to be determined. He concluded that either the observed anomalies were due to magnetic phases within the Mathinna units or due to magnetic granites beneath the Mathinna units. Roach suggested a third possibility, that the magnetic and gravity anomalies observed for the Mathinna units were due to physical property variation related to the effects of granite intrusion.

The aims of this project were to utilise the new high resolution data to remodel some of the earlier interpretations in order to ascertain if the third alternate approach could also explain the anomalies and be better correlated with the distribution of gold mineralisation. Such a solution could also provide a geophysical signature for the genesis of some styles of gold deposits that may be used in future exploration.

2 Geophysical data

As part of the 2006 TasExplore initiative to promote mineral exploration in the state, Mineral Resources Tasmania funded the acquisition of aeromagnetic and radiometric data over northeast Tasmania. The data acquisition was flown by fixed wing aircraft and helicopter with east – west flight lines spaced 200m apart with nominal 90m terrain clearance. The data were levelled using tie lines (spaced 2,000m apart) and after applying corrections were interpolated to 40m grid cells. All coordinates are AGD66 Zone 55.

The gravity data is subset from the Tasmanian residual gravity database which has been produced by correcting the Bouguer gravity data for the effects of Moho topography and the bathymetry of the waters surrounding Tasmania at each data point (Leaman and Richardson, 1987).

3 Geology and physical properties

The geology of the area is basically composed of Ordovician to Lower Devonian sediments of the Mathinna Supergroup which have been intruded by Middle Devonian granitoids. The Mathinna Supergroup comprises up to 7km thickness of turbidite sandstone and black pelite which forms the pre-Carboniferous basement to eastern Tasmania (Seymour, etal, 2007). The granites vary in composition from unfractionated I-type granitoids to felsic fractionated I-type to dominantly S-type in the east with appropriate physical properties (Table 1).

Physical properties of Tasmanian rock types have been collated by the Geological Survey and within the NE Tasmanian area by Roach (1994) and the values used in this model study have been maintained within the ranges summarised below. The distribution of Tasmanian granitoids with depth has been determined from modelling of the regional gravity data (Leaman and Richardson, 2003) and it has been observed that the significant granite-related mineral deposits lie within the 4km depth range (Seymour, etal, 2007). However, as noted by Roach, there is little variation between the physical properties of the Mathinna units and some granitoids thus making it difficult to uniquely model the disposition of geology to explain the observed magnetic and gravity anomalies.

Table 1

range of physical properties used in model study				*M. Roach (1994)*	
Unit	*min Susc*	*max Susc*	*density*	*Susc (SI)*	*density*
Jurassic Dolerite	*0.0018*	*0.0022*	*not used*	*0.02*	*2.9*
Scottsdale Gr	*-0.0001*	*0*	*2.60 -2.63*	*0.00005*	*2.61*
DIDDLEUM Gr	*0*	*0.0001*	*2.75*		
Tombstone Gr	*0.0001*		*2.60 - 2.62*		
Porcupine Gr	*0.0001*	*0.0002*	*2.69*		
Pyengana Gr	*0.0004*		*2.7*	*0.00025*	*2.75*
Unknown Granite	*0*		*2.70 -2.75*		
Mathinna Group	*0.0001*	*0.0003*	*2.73 - 2.75*	*0.0002*	*2.75*
Mathinna Group (altered)	*0*		*2.70 - 2.71*		

4 Qualitative analysis

Prior to commencing the model studies of the various geological scenarios, it was necessary to establish the geophysical signature of the Mathinna units and the various granitoids. As illustrated in Figure 1, the TMI image of NE Tasmania is dominated by the broad high centred near Bridport and extending at least half way to the east and south of the survey area. The anomaly is not strong, of the order of 15 -20 nT, but its shape and lateral extent indicates that it is due to a deep source and Roach (1994) proposed that its source is a deep, flat to shallow east dipping ultramafic.

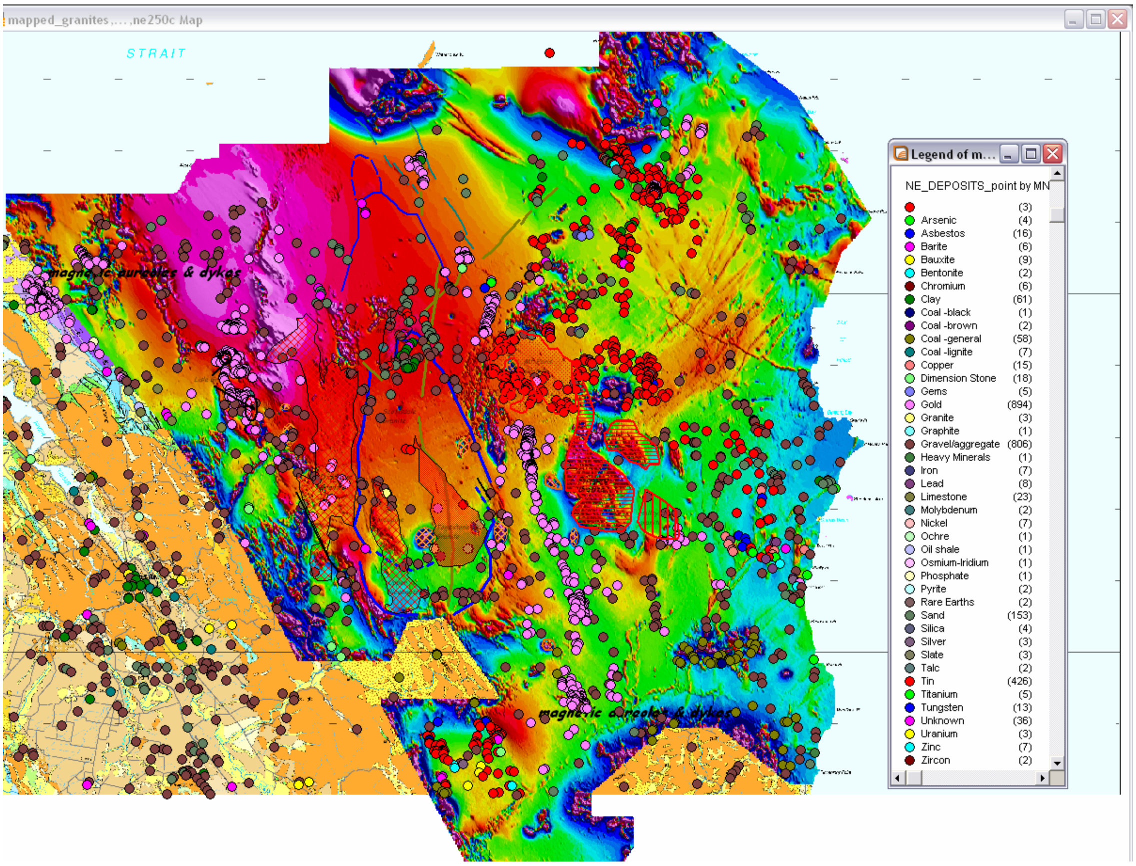

Figure 1. TMI image of NE Tasmania with mineral occurrences superimposed

This broad regional magnetic anomaly feature is obviously obscuring the subtle anomaly patterns due to Mathinna units and Devonian intrusives, so several filters were tested in an attempt to remove the regional anomaly and expose the residual anomaly patterns due to shallow geology. A simple high pass filter with wavelength of 100km was found to be adequate to remove the deep seated anomaly pattern and leave the residual anomaly pattern shown in figure 2 and in figure 3 with mineral occurrences superimposed.

The residual TMI image shows several clear features that can be immediately related to shallow geology:

i) a residual anomaly complex near Bridport that will be analysed in chapter 5a
ii) TMI high and low patterns that can be correlated with outcropping granitoids
iii) Variable anomaly patterns over Mathinna units outcrops that will be studied in chapter 5b
iv) A relationship between magnetic and gravity anomalies and clusters of gold occurrences that will be discussed in chapter 6

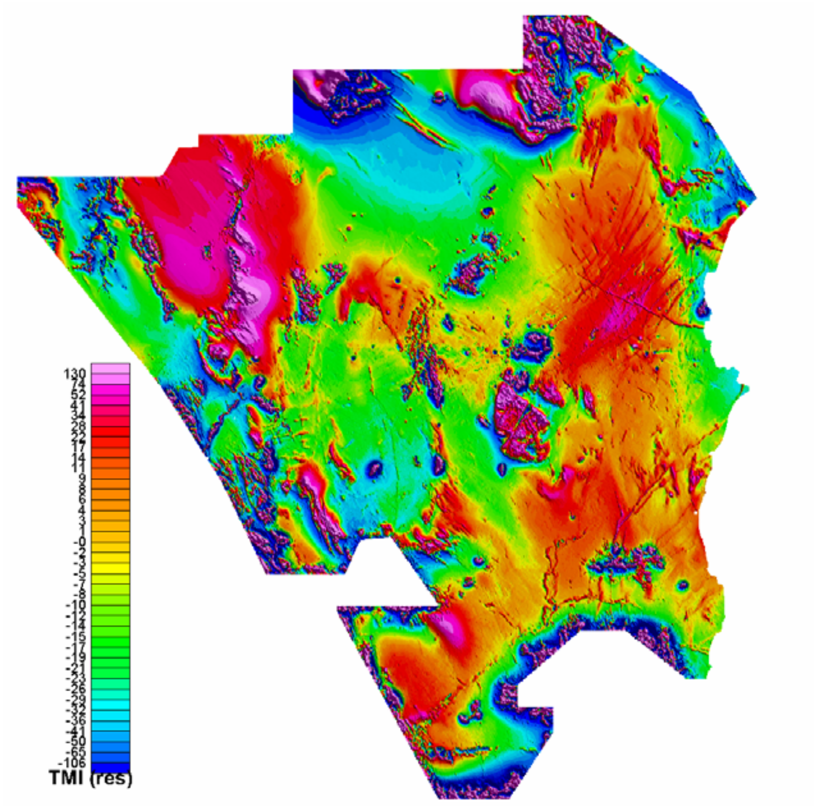

Figure 2. Residual TMI image after removal of regional anomaly

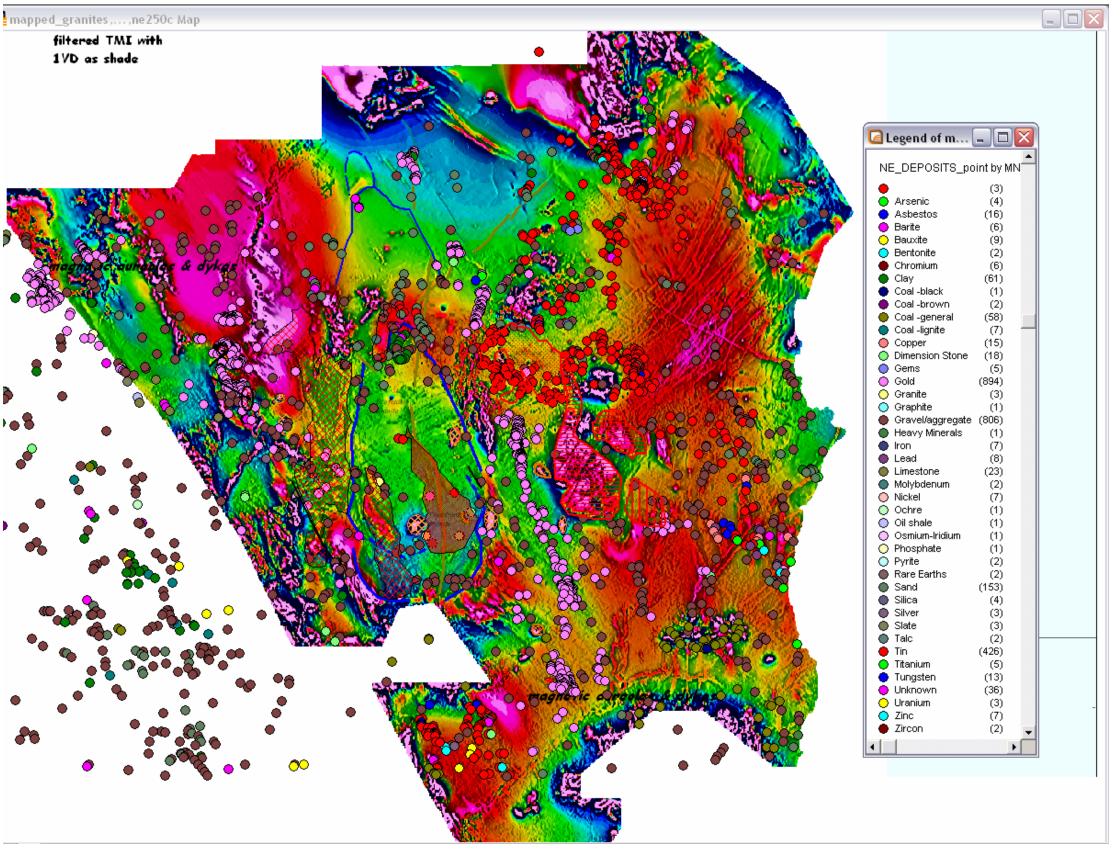

Figure 3. Residual TMI image showing some granitoids and mineral occurrences

The gravity data for NE Tasmania (fig 4) is dominated by an east-west change in amplitude of the order of 30 mgals that is defined by a sharp N-S trending gradient. This gradient essentially marks the change between high density granitoids on the west and low density granitoids in the east. In part the gravity gradient is located at the contact between the Diddleum granite and Scottsdale Batholith, however, the gradient extends N-S well beyond the outcrop of these granitoids and obviously maps a more significant geological contrast. The significance of this gradient will be tested by model analysis.

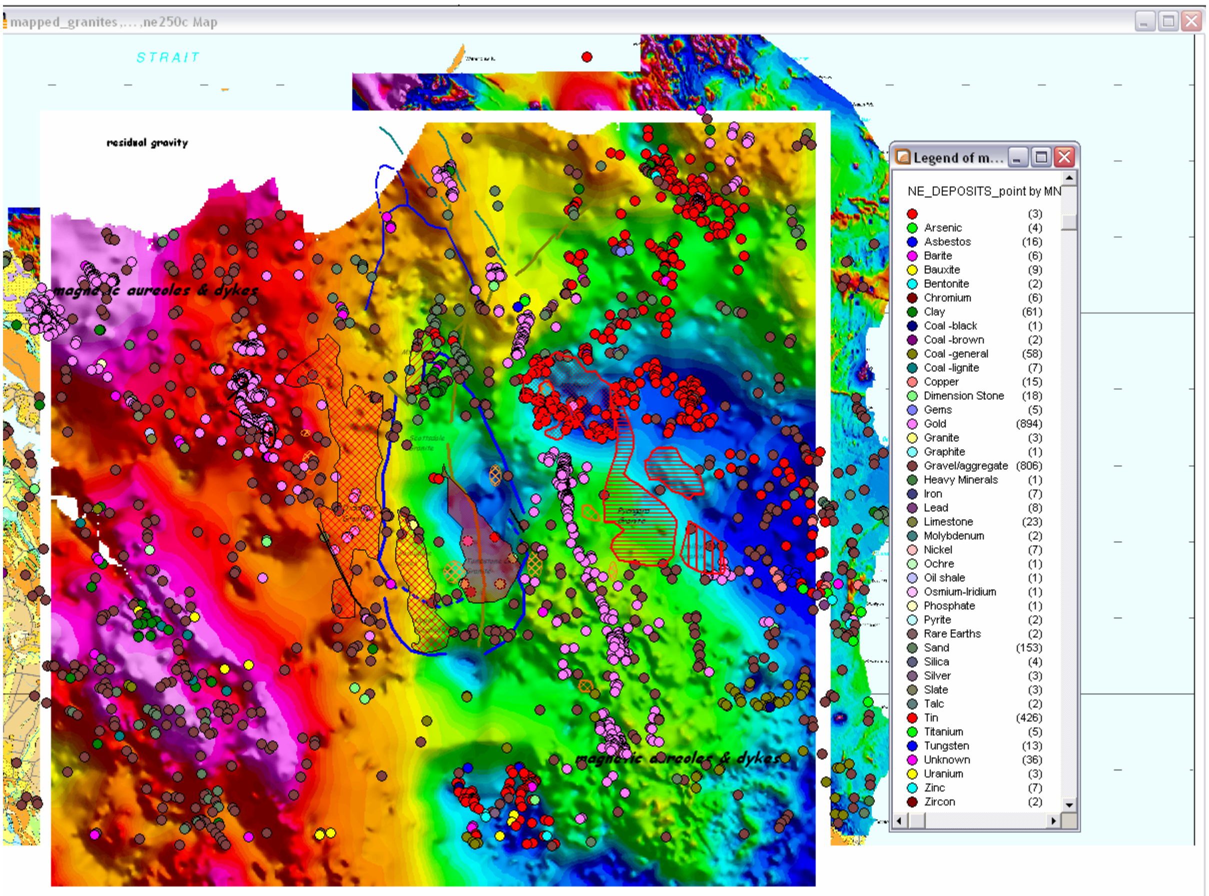

Figure 4. Gravity image for NE Tasmania with some granitoids superimposed and also showing mineral occurrences.

The regional gravity pattern masks the subtle anomalies due to shallow geology, in particular the anomalies caused by granitoids. Several attempts were made to remove the regional gradient and the most suitable operator was found to be a high pass filter with cut-off wavelength of 100km, as with the magnetic data, to produce the residual gravity image shown in figure 5a. This image can be more easily correlated with the granite outcrop, as mapped, in particular the symmetry and extent of the Scottsdale batholith are well defined (Fig 5b). Many of the gold occurrences in the area of interest (such as the Lisle, Lefroy, Lyndhurst Goldfields and the Alberton to Mathinna gold corridor) are observed in figure 5b to be located in association with residual gravity highs and this signature will be discussed in section 6.

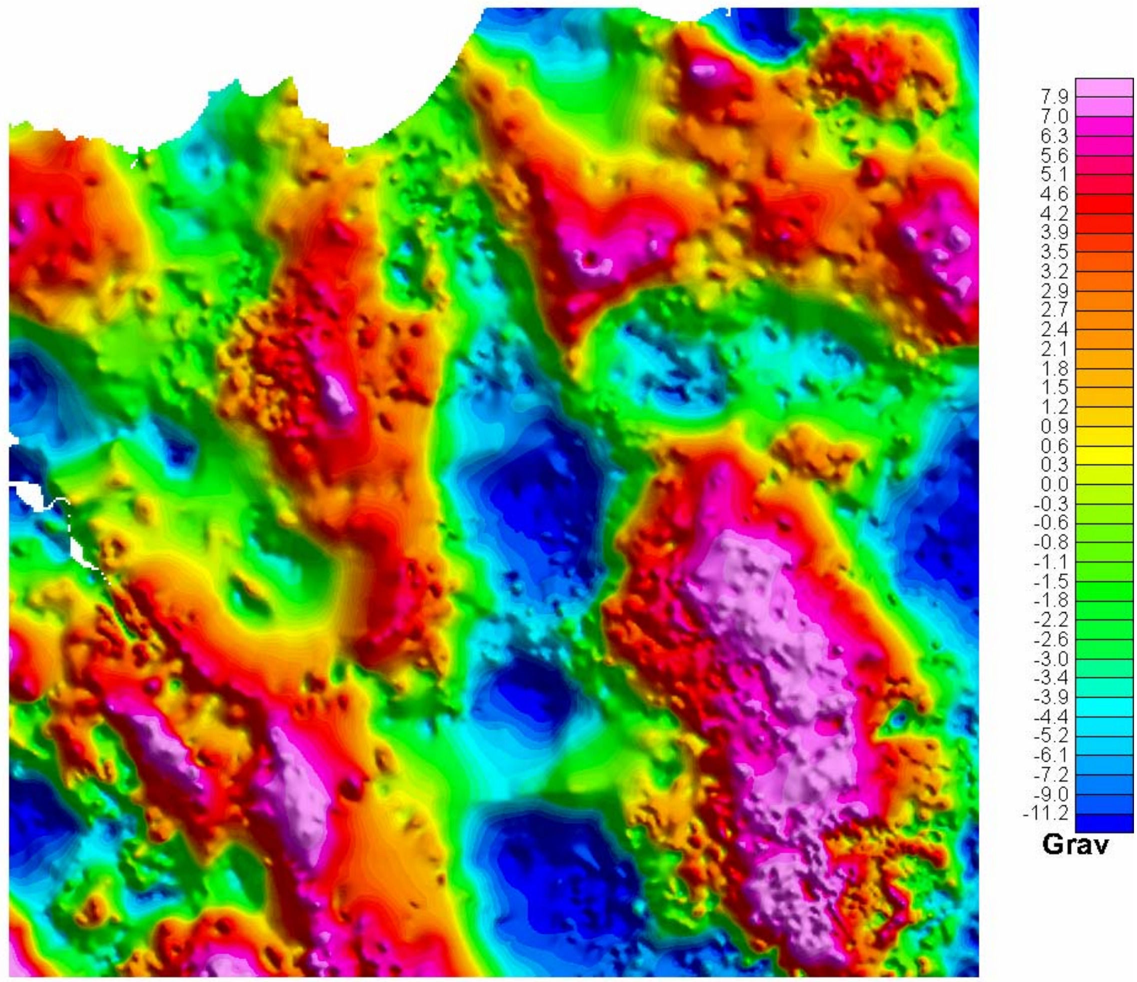

Figure 5a. Residual gravity pattern for NE Tasmania

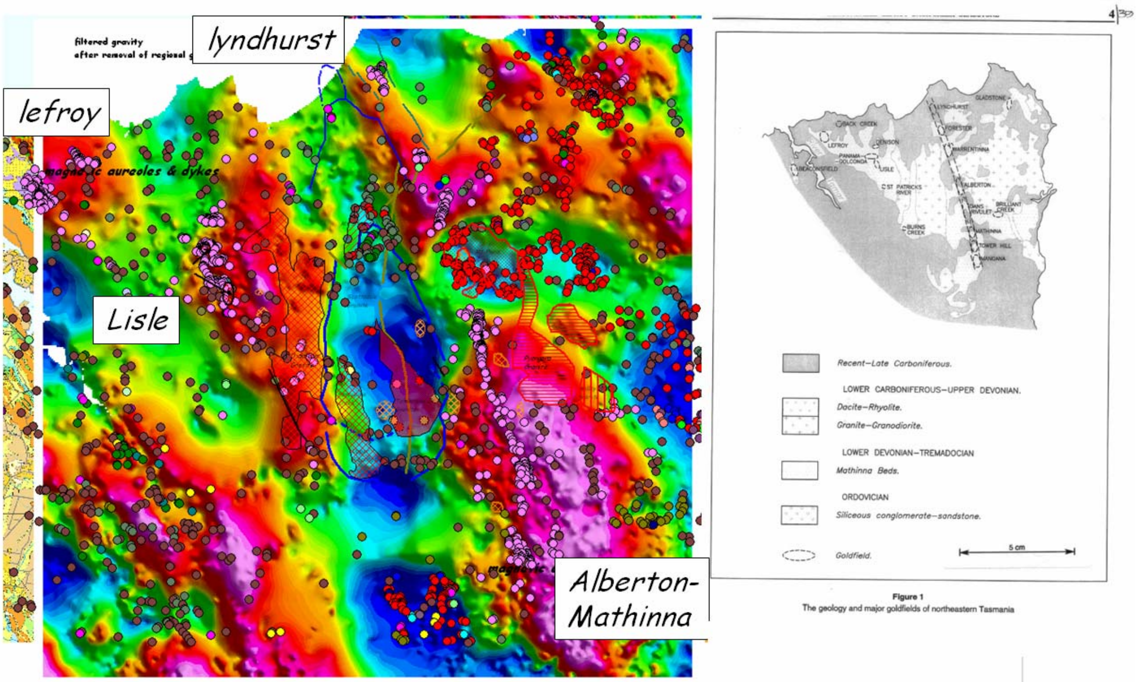

Figure 5b. Residual gravity with mineral occurrences and granite outcrop superimposed

Utilising these residual magnetic and gravity grids allows the recognition of a qualitative signature for the shallow expression of the various granitoids as listed in Table2 and portrayed in figures 6, 7 and 8.

Table 2

Qualitative signature of granitoids

Granitoid	magnetic	gravity
Lisle (limited outcrop)	multi-phased & strong aureole	flank of high, complex grain
Diddleum	mag low, weak aureole	flank of high, some grain
Scottsdale	mag low, weak aureole	strong gravity low (less in N)
Porcupine	magnetic high	moderate gravity
Blessington	magnetic low	moderate gravity
Tombstone	nil magnetic grain	gravity low
Mt. Stronach	magnetic high	low order gravity high
Mt. Paris	mild grain, no aureole	good gravity low
Pyengana	strong magnetic high	moderate gravity high
Halley's	mild grain, aureole	flank of high, some grain

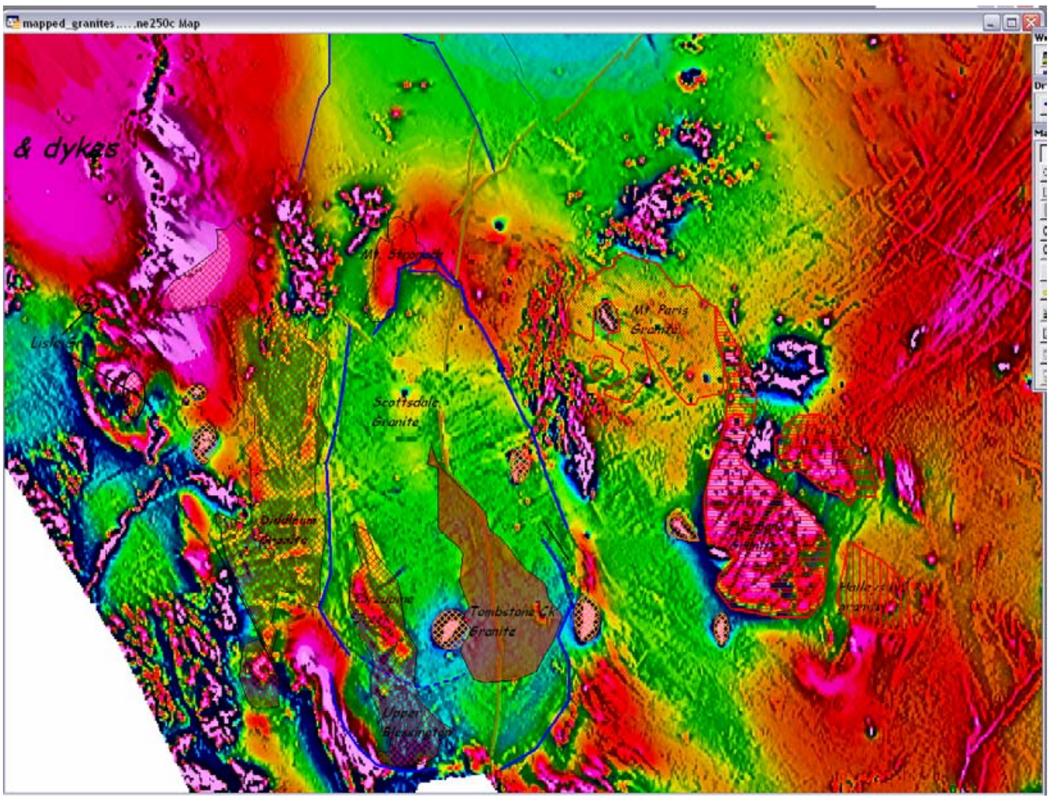

Figure 6. Residual TMI image of Bridport – Mathinna area with outline of granite outcrop

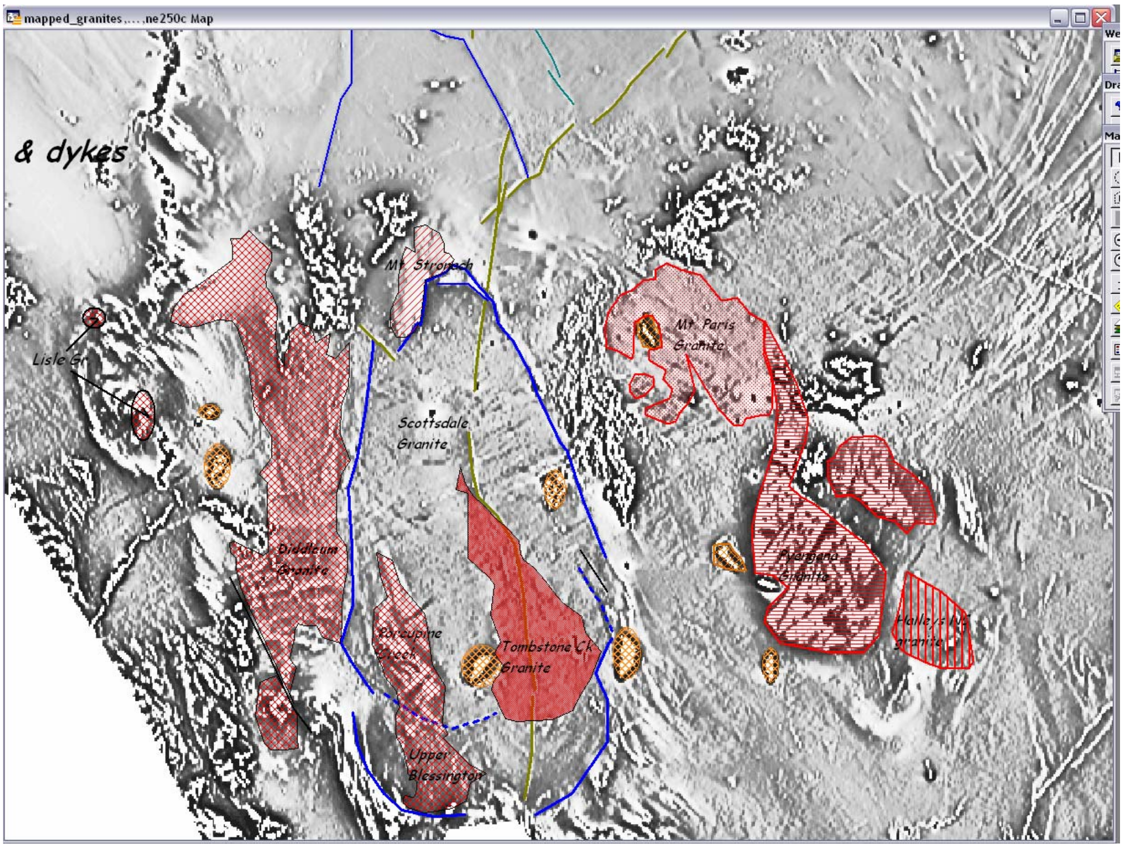

Figure 7. Vertical derivative of residual TMI showing signature of various granitoids

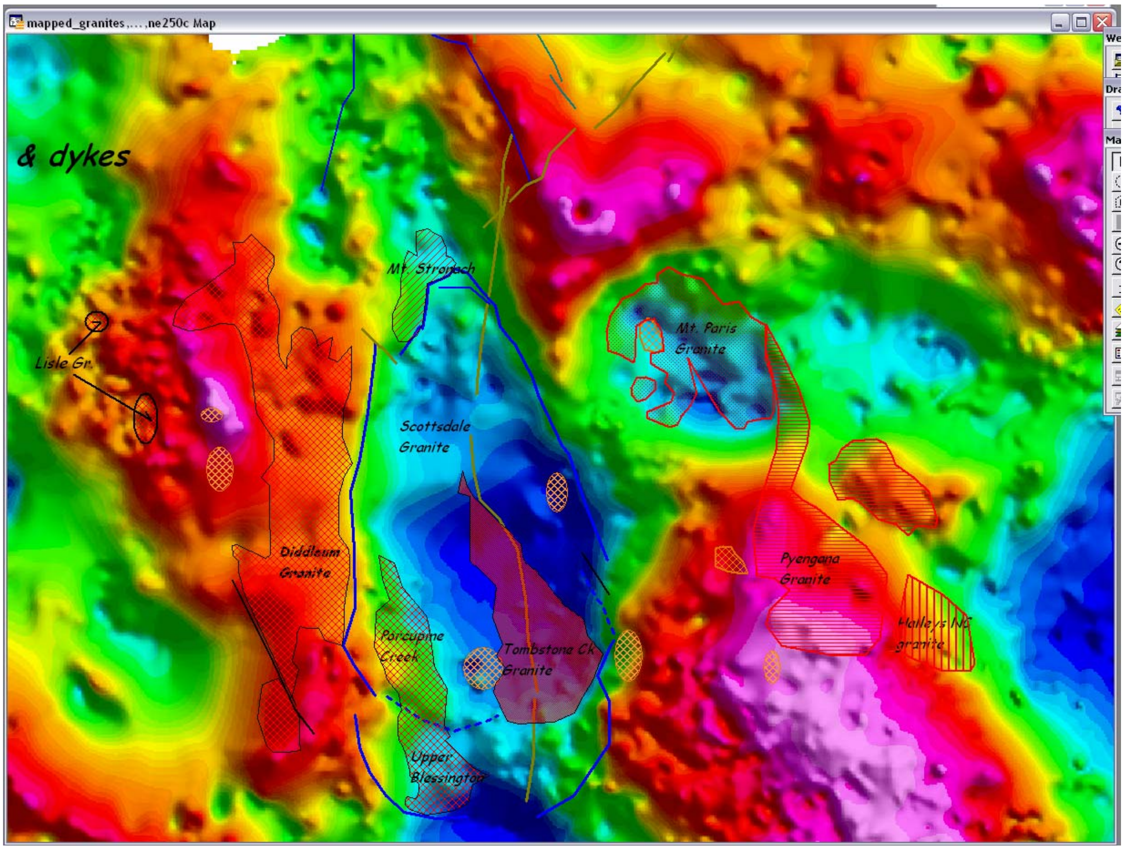

Figure 8. Residual gravity image showing signature of various granitoids

5 Quantitative analysis

a) Deep ultramafic: Bridport models

The TMI data image (Fig 1) shows that a significant portion of the survey area is dominated by a broad anomaly of only 15 - 20nT relief. Such a broad anomaly must be due to a deep seated source and Roach (1994) used a flat lying ultramafic of moderate susceptibility (0.05 SI), at ~8 km depth, to explain the anomaly. This interpretation has been checked by Seymour, using the new dataset, (pers. comm., 2007) along a NE-SW profile across the anomaly (Fig 9) thus supporting Roach's analysis. In these figures, local magnetic anomalies due to shallow basalt have not always been modelled in detail.

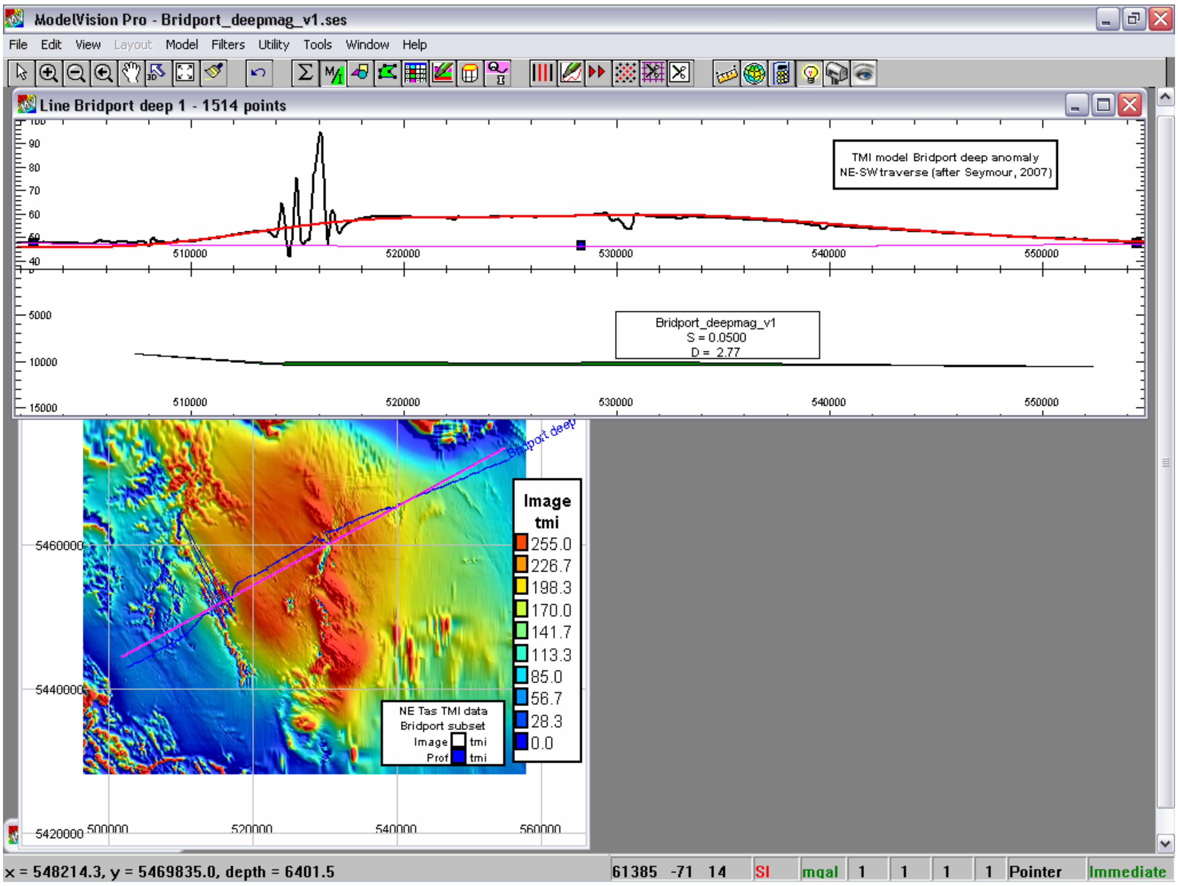

Figure 9. Model of TMI profile across the broad anomaly near Bridport.

However, Seymour noted that an E-W profile (Fig 10) located to the south, but still crossing the earlier traverse, contained additional anomaly features (at 530,000E) that could be explained by an uplift of the ultramafic to only 5km depth. Such an uplift of the ultramafic could be explained by the N-S trending fault that is interpreted to be related to the outcrop of basalt through the area. An additional E-W magnetic profile (Fig 11), located only 4km to the North, does not show the necessity for the same uplift of the ultramafic unit and an alternate, shallower source is required.

Detail of the residual TMI image, shown in Fig 12, shows NW – SE trending linears that are interpreted to reflect the recumbent folding of the Mathinna units. Indeed the approximate N-S trend of Tertiary basalt appears to be offset in a sinistral movement by these NW trending structures. Figure 13 shows the residual gravity data for the same area which supports the proposed continuation of the Diddleum granite to the north.

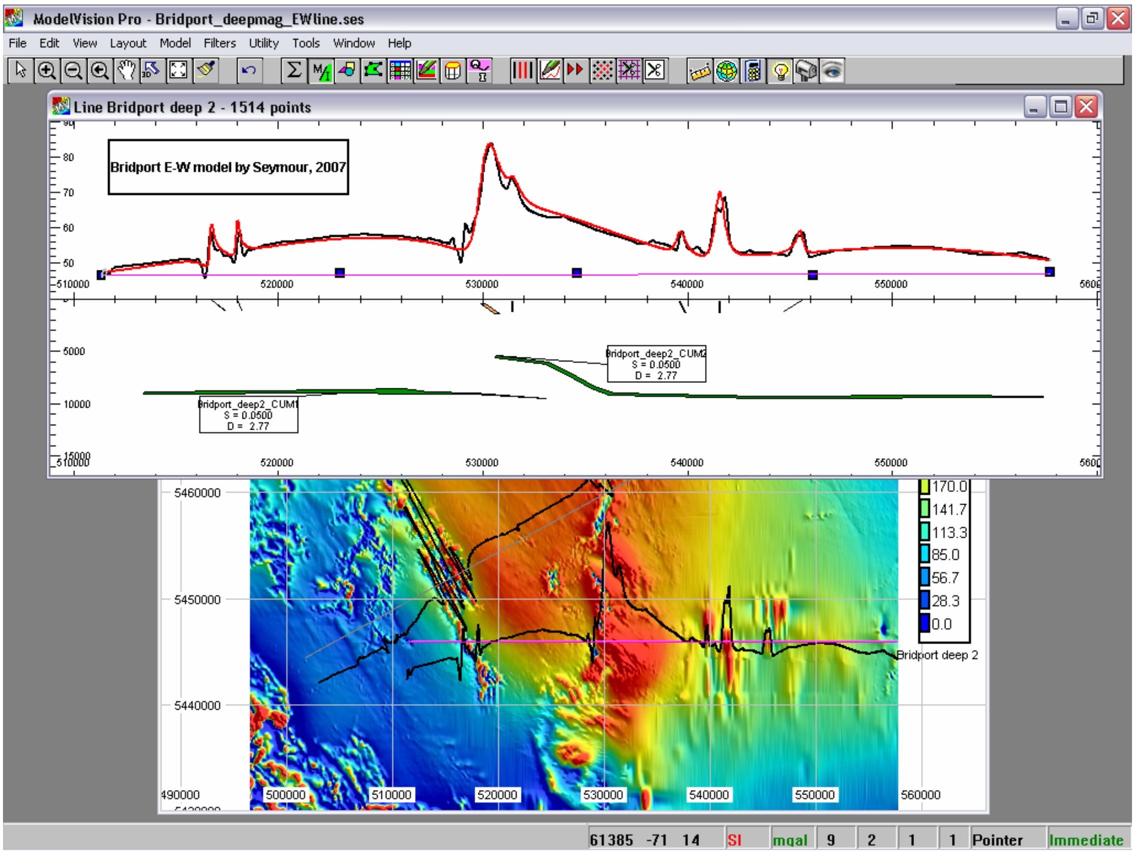

Figure 10. model of E-W traverse across the Bridport magnetic anomaly.

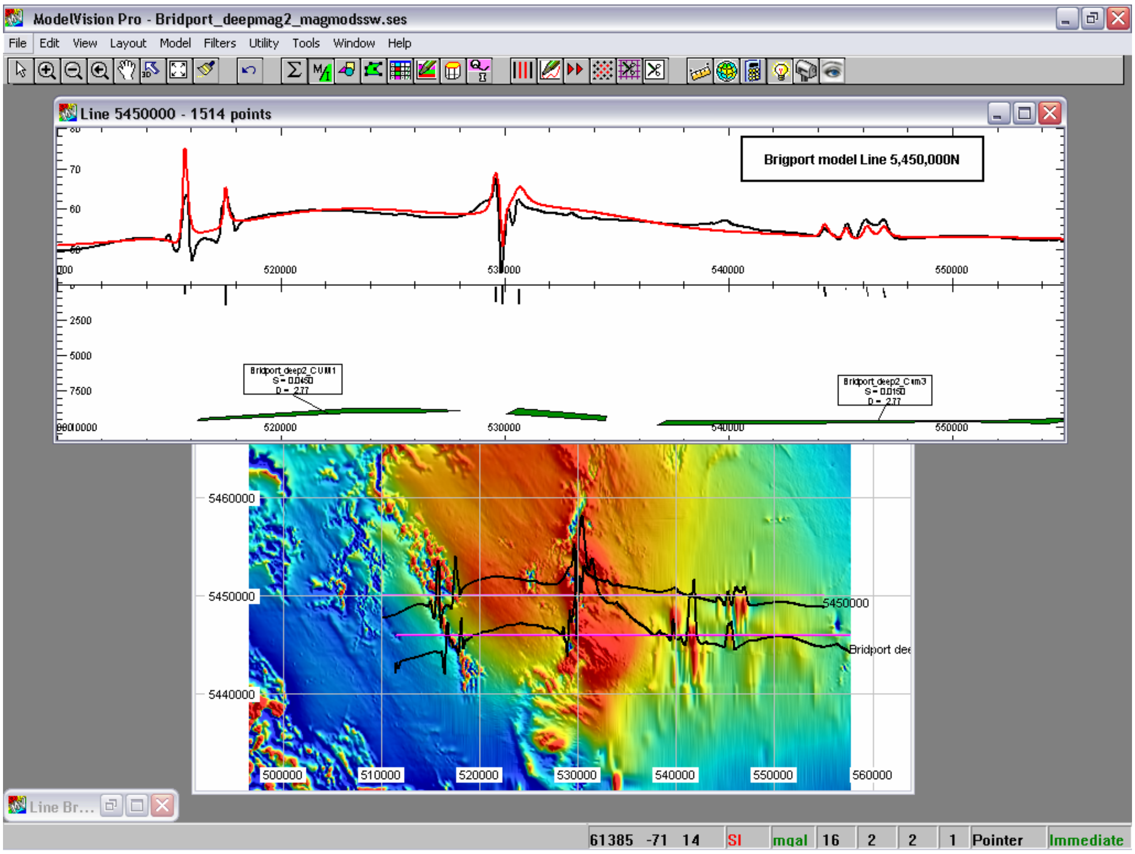

Figure 11. Model of additional profile across the Bridport magnetic anomaly

Also shown in Fig 12 is the mapped outcrop of the Diddleum Granite which flanks the eastern trend of the local residual magnetic anomalies. It is interpreted that the Diddleum granite continues to intrude the Mathinna units to the north of outcrop (dashed line) and thermal alteration has locally increased the magnetic grain of the units, thus generating the shallow magnetic anomalies. This proposal is tested (Fig 14) by generating magnetic and gravity models of this scenario and it is shown that the anomaly pattern can indeed be explained by shallow sources related to physical property changes (susceptibility increase from average of 0.0002 SI to 0.0005 SI) in the Mathinna units.

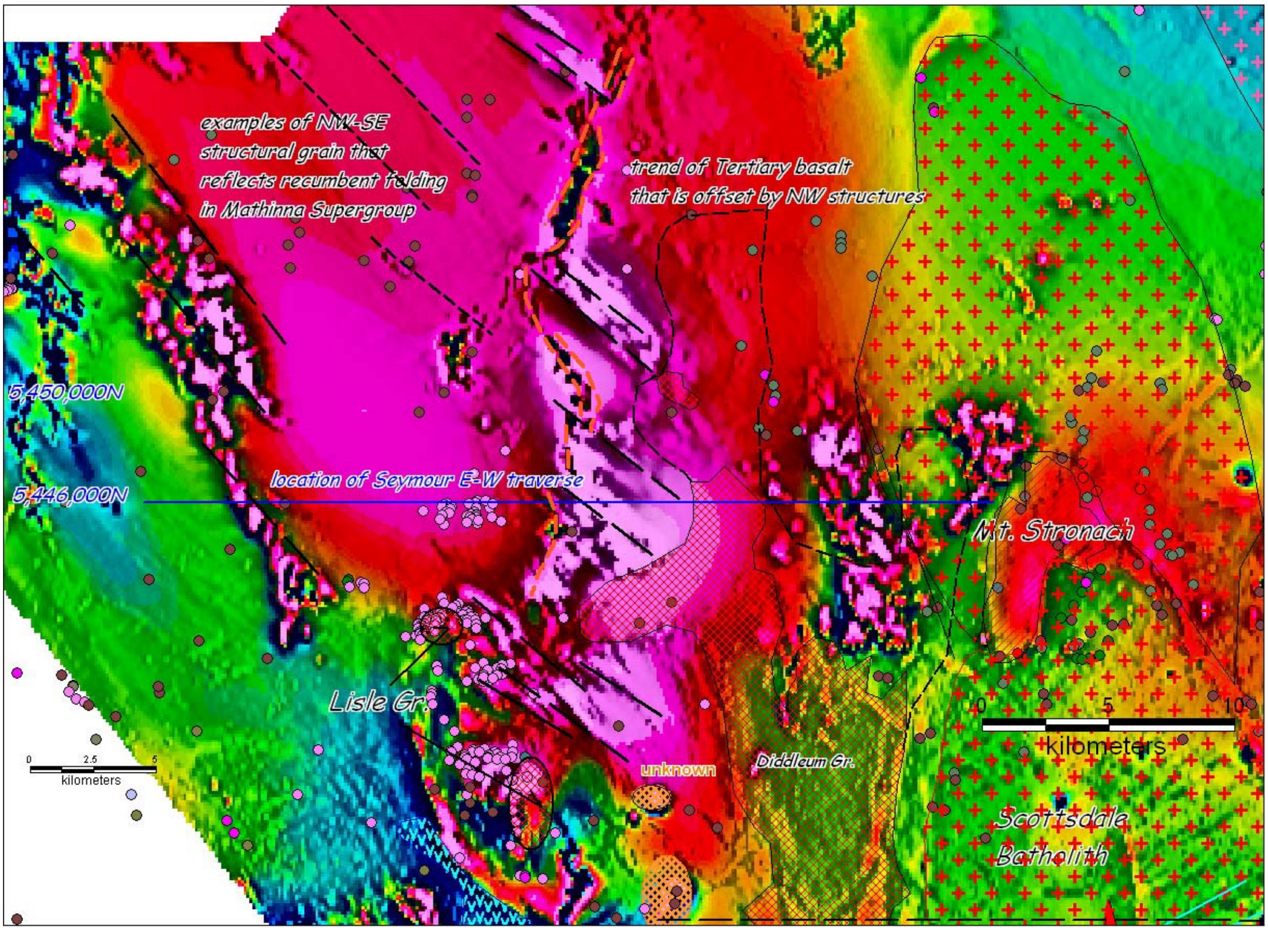

Figure 12. Image of residual TMI showing shallow grain within Mathinna units

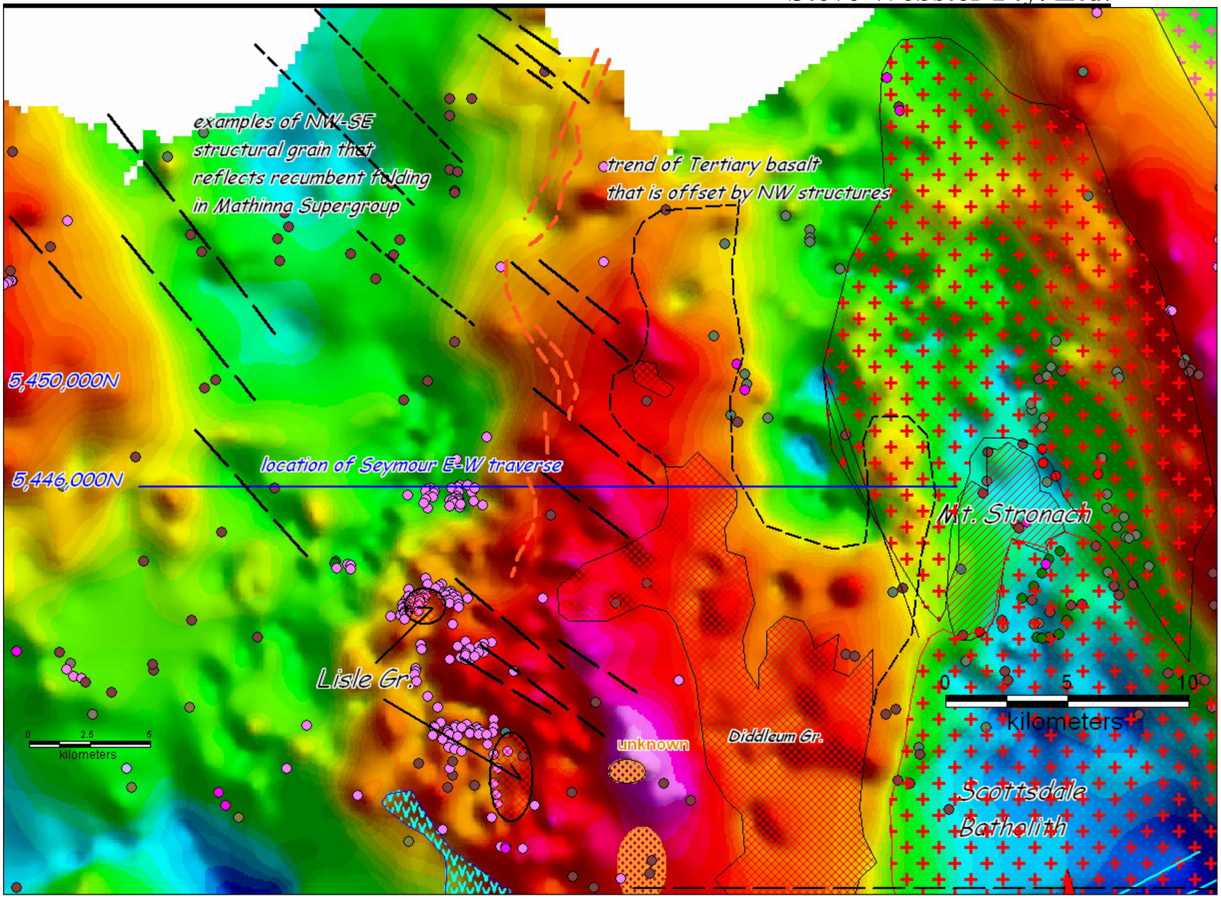

Figure 13. Residual gravity data for the Bridport area with interpreted features.

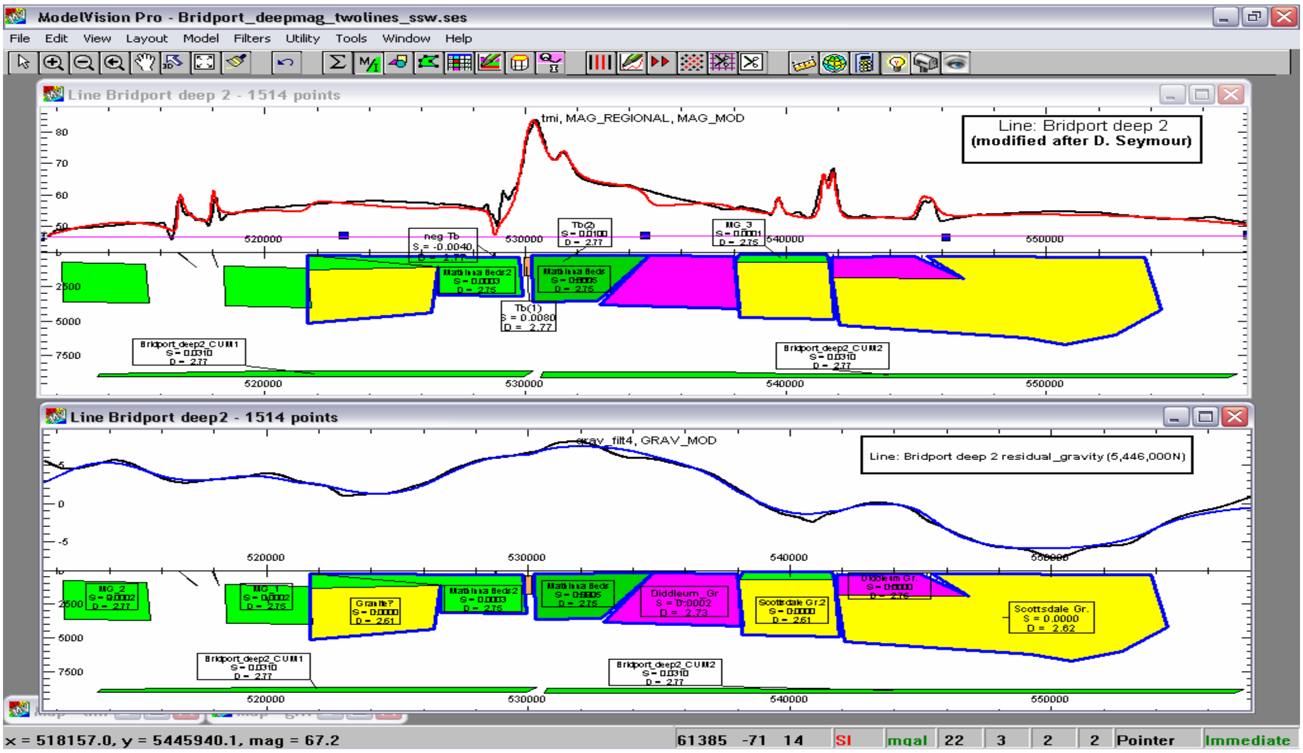

Figure 14. Magnetic and gravity models of traverse along 5,446,000N

To the east of Bridport, the Lyndhurst goldfield (fig 15) is located in a NNW trending wedge of Mathinna units between the northerly extension of the Scottdale Batholith on the west and the Blue Tier granite to the east.

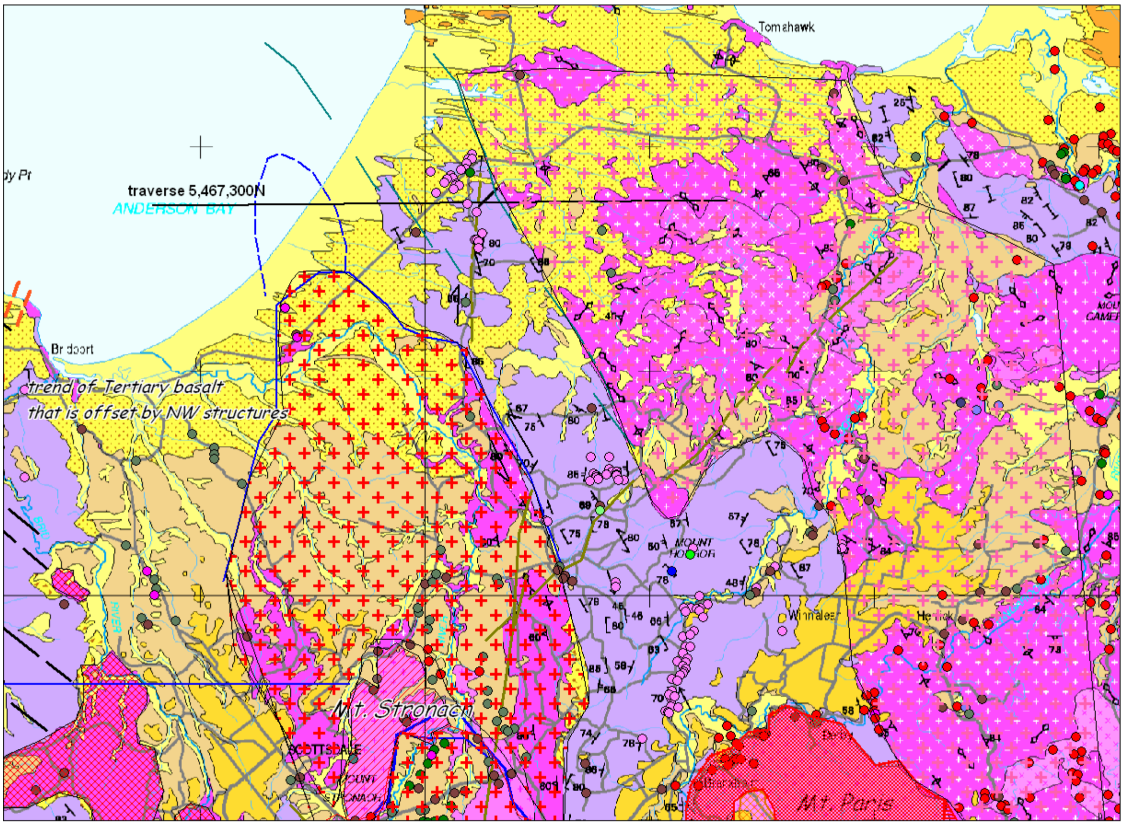

Figure 15. Geology in the vicinity of the Lyndhurst goldfield

The residual magnetic and gravity pattern (Fig 16) in the vicinity of the Lyndhurst goldfield show both the Blue Tier and Scottsdale granites as magnetic and gravity lows with the Mathinna units as a NNW trending gravity high. There is little to no magnetic expression of the Mathinna units, except for a linear aureole (or dyke) at the Blue Tier contact and a NNE trending dyke within the Mathinna units.

Also evident in the magnetic data is a narrow dyke that trends consistently N-S through the Scottsdale granite for some 50 km. At the northern edge of the Scottsdale granite the dyke is displaced some 6 km to the north and then continues across the Mathinna units. The dyke has not been mapped to outcrop, so its nature is unknown.

A magnetic profile, along 5,467,300N, crosses the northern continuation of the Scottsdale granite and the Mathinna units near the Lyndhurst goldfield and extends into the Blue Tier granite on the east. The model study suggests that the Scottsdale granite in the north is thinner and denser than in the south and bounded by a thin magnetic aureole. The Blue Tier granite underlies the Mathinna units, which vary from 2 -4 km in thickness and exhibit reduced density. The dykes in the Mathinna appear to dip steeply to the east.

In the vicinity of the Lyndhurst goldfield, the Mathinna units appear to have reduced susceptibility and density which may be a factor of reactive units being altered by the Blue Tier granite, especially in the proximity of the north trending dyke, which may suggest a structural setting favourable for the deposition of gold mineralisation.

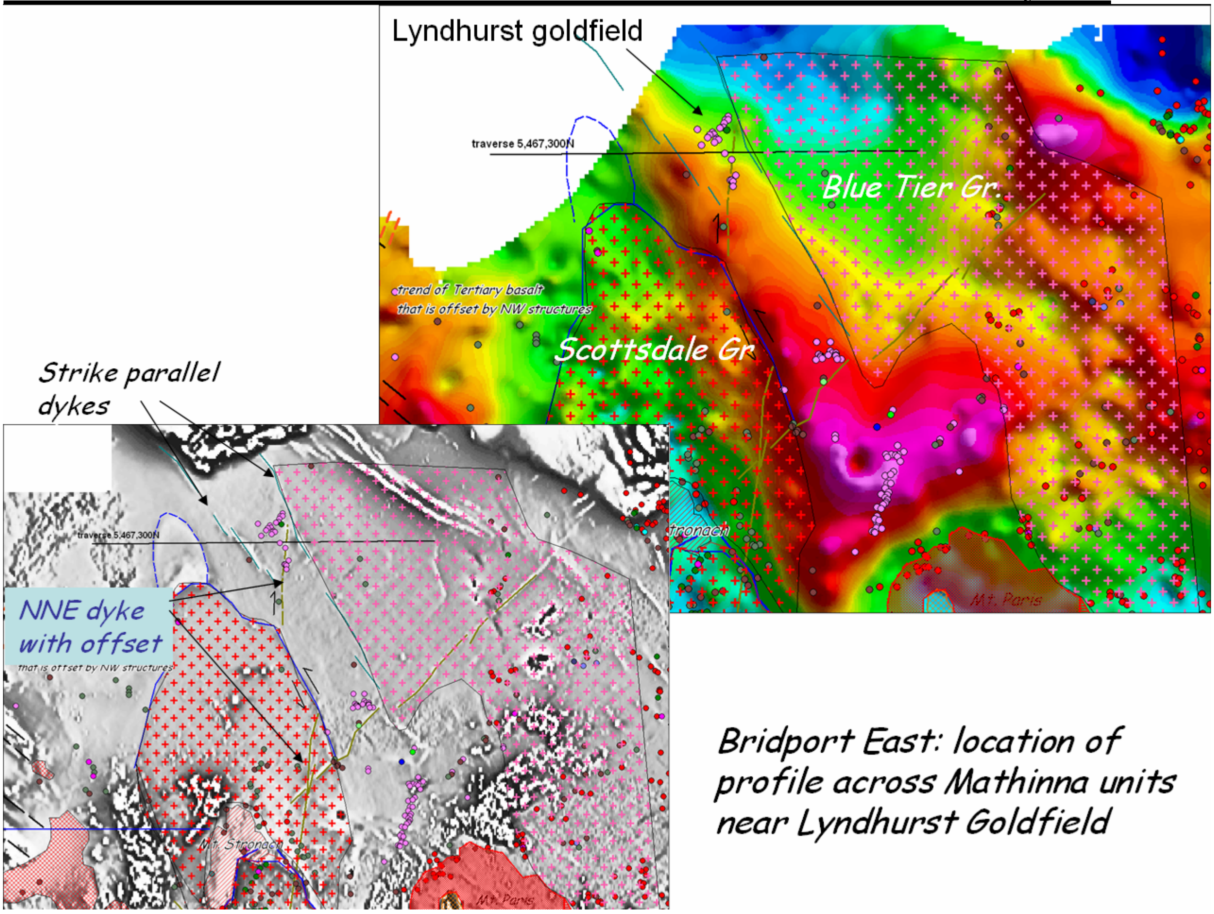

Fig 16. Residual gravity and magnetic image in vicinity of Lyndhurst goldfield

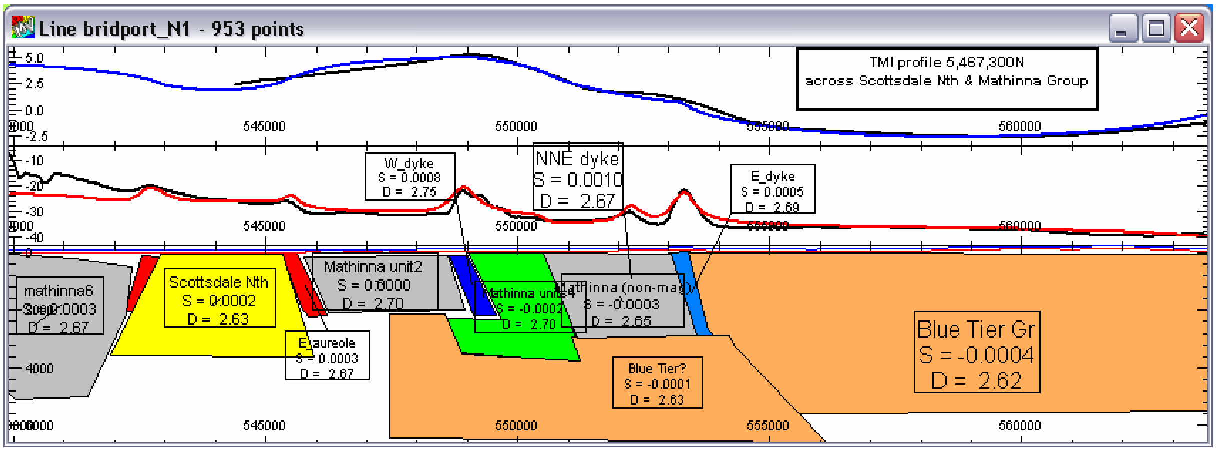

Figure 17. Model of residual TMI and gravity profile near Lyndhurst goldfield

b) Mathinna Super Group: Roach models

Geological mapping of the central portion of NE Tasmania (figure 18) shows the area to dominantly comprise units of the Mathinna Supergroup which are intruded by Devonian granitoids of various, but essentially I-type, composition (Seymour, 2007). The area shown is strongly mineralised, with gold as the economically significant commodity.

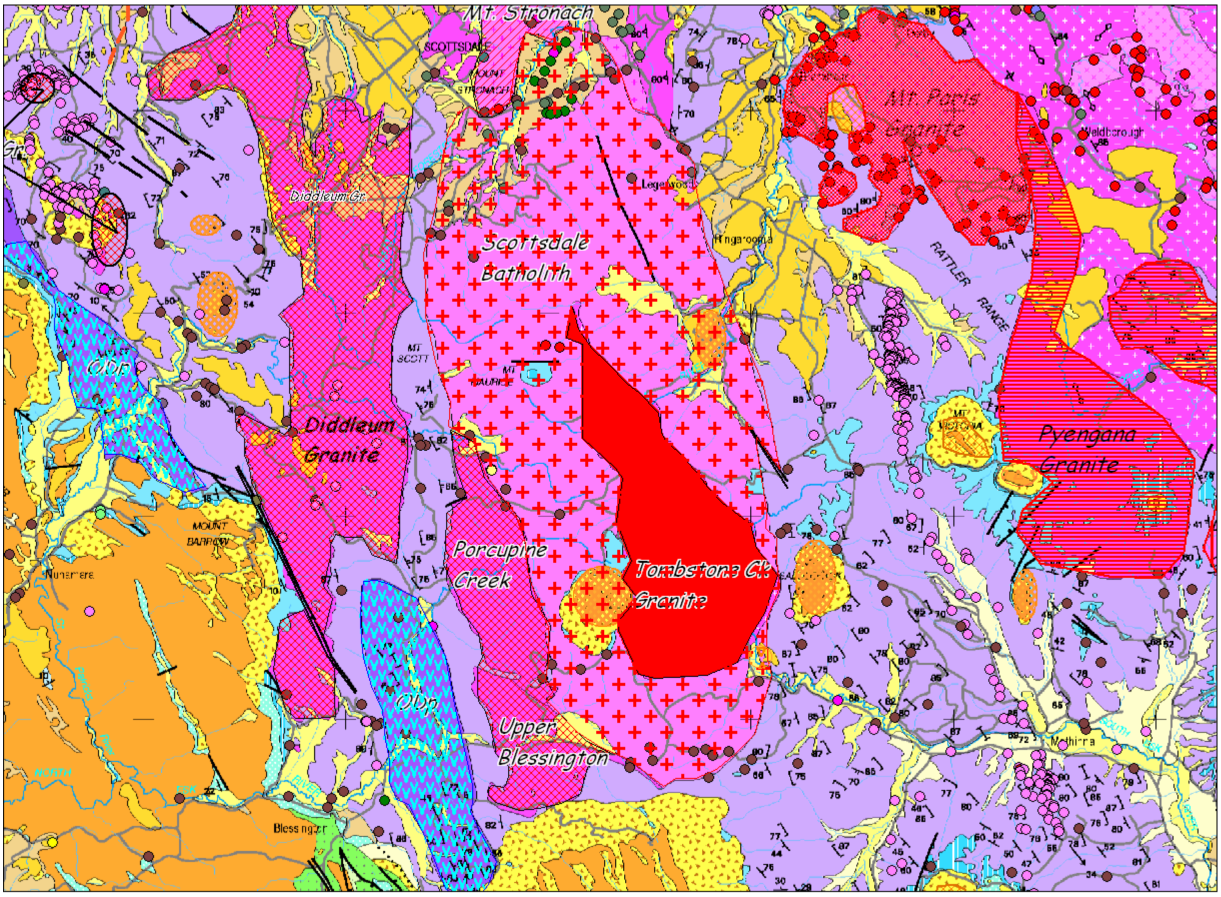

Figure 18. Geology map of central portion of NE Tasmania showing mineral occurrences

The Mathinna units surrounding the Scottsdale Batholith (fig 19) show a variable magnetic grain that indicates moderate amplitude relief (50 -100nT) on the SE and SW margins of the intrusive and reduced to zero anomalies along the Alberton – Mathinna 'gold corridor'.

Four TMI traverses, spaced 7 km apart, (shown in fig. 19) were interpolated to model the variable responses of the Mathinna units and cross other lithologies at the sites of notable features in the new magnetic data set. The southernmost traverse (5,409,000N) is located 2km to the north of Roach's 5,407,000N traverse, and the northern traverse (5,430,000N) is 2km to the north of Roach's traverse NE3 (5,428,000N).

Roach's modelling of the 5,409,000N traverse did not cross the Scottsdale granite but incorporated its presence at depth beneath 2.5 km thickness of Mathinna units, this thickness was interpreted by Roach from sensitivity analysis of models to the data. He used two alternate models to illustrate the fact that the similarity between the physical properties of the Granite and Mathinna units precluded the determination of a unique solution. One model used magnetic Mathinna units as the source of magnetic anomalies and the other used magnetic granites as the source material.

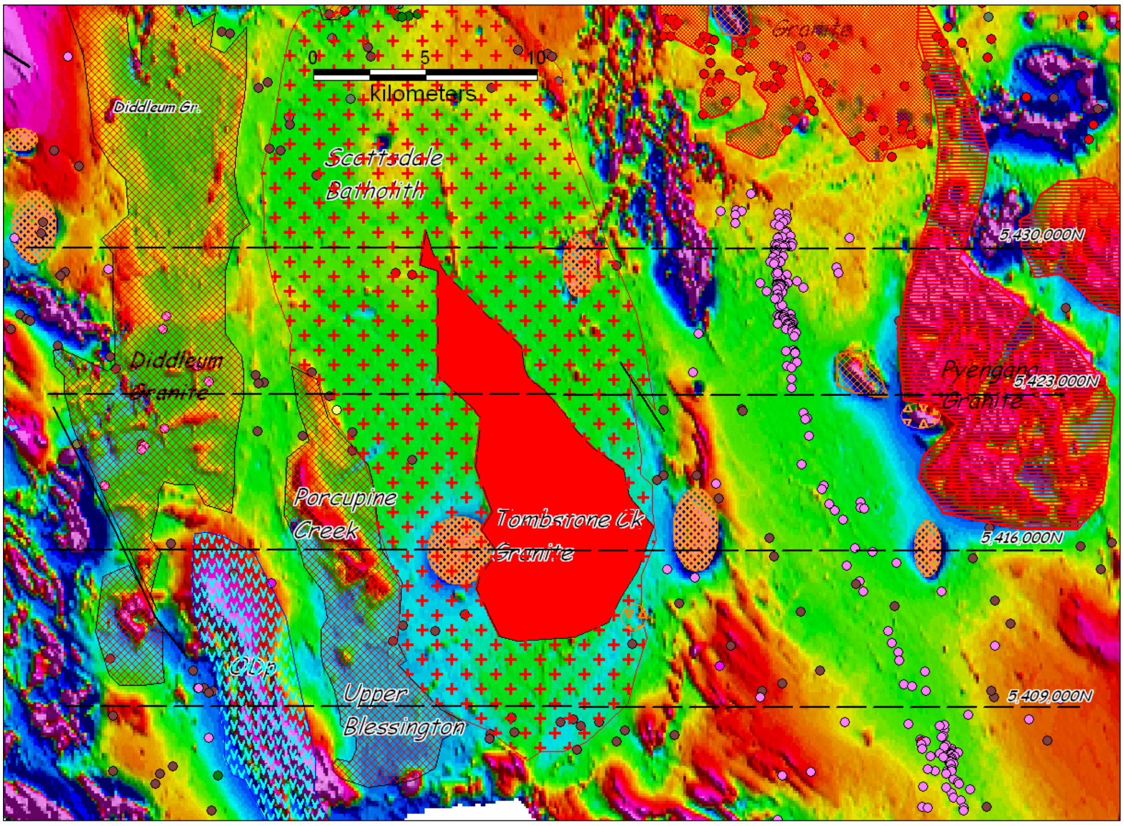

Figure 19. TMI image of the area surrounding the Scottsdale Batholith

Roach proposed a third alternative model, that the magnetic anomalies were due to variations in the susceptibility of the Mathinna units and this idea has been incorporated into the model of line 5,409,000N, as shown in figure 20. In the model section there is some apparent distortion of the projected unit shapes, as the Scottsdale and Blessington granitoids trend N-S while other units are assumed to trend NNW. The Blessington and Scottsdale granites are shown to have susceptibilities below background while Mathinna unit susceptibilities vary between the adopted range of 0.0001 and 0.0003 SI units, while maintaining the 2km thickness estimated by Roach. To explain the gravity high in the west, it is an option to continue the Diddleum granite to the south of its outcrop limit rather than assume a greater thickness of the Mathinna units in this vicinity. This assumption also follows the pattern of the gravity anomaly grain as observed in figure 8.

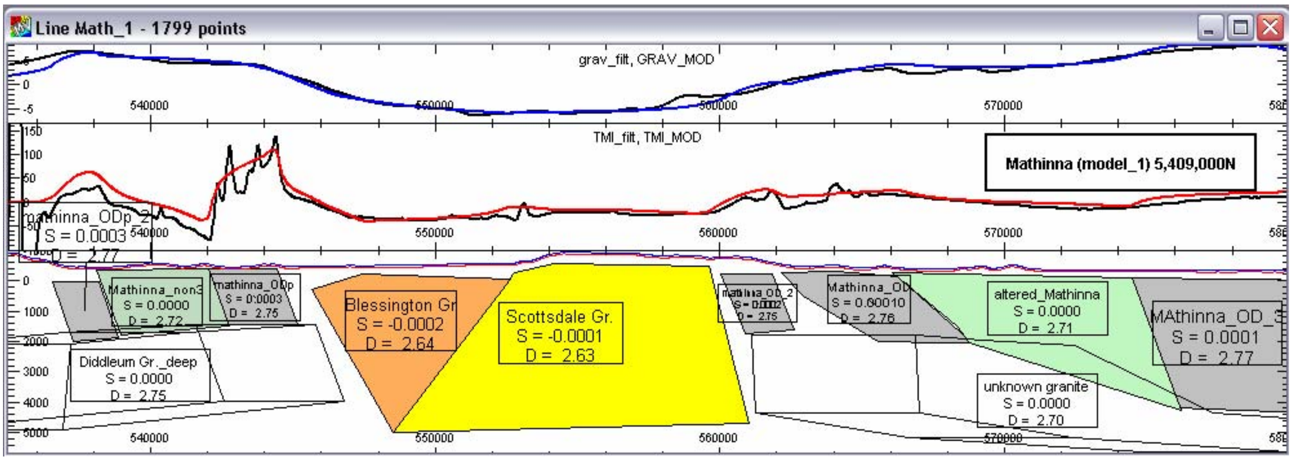

Figure 20. Model of TMI traverse 5,409,000N

Within an aureole on either side of the granites, the Mathinna units are slightly more magnetic than observed elsewhere and produce a set of sharp, linear highs (+/-25 nT) which indicate that sub-units are more reactive than the whole sequence. These individual anomalies have not been modelled in detail and an accumulated anomaly shape has been modelled to suggest that a contact metamorphic effect as the source of the enhanced susceptibility.

In the east, the broad gravity high and reduced magnetic response (fig 20) suggests either that the Mathinna units are thicker over the extent of the gravity high or that they are underlain by an unknown granite. The presence of alteration due to such a granitoid would help to explain the apparent lower density and susceptibility of the Mathinna units and the occurrence of gold mineralisation, which would not be the case for the assumption of thicker Mathinna units.

Traverse 5,416,000N (fig 21) crosses several phases of the Scottsdale batholith and three remnant dolerite features that complicate the magnetic anomaly pattern, however, the models agree with those for the adjoining traverses. The strong magnetic anomalies due to remnants of dolerite on hilltops can be simply modelled, but their effect dominates the profile and makes it difficult to resolve subtle features due to other geology .

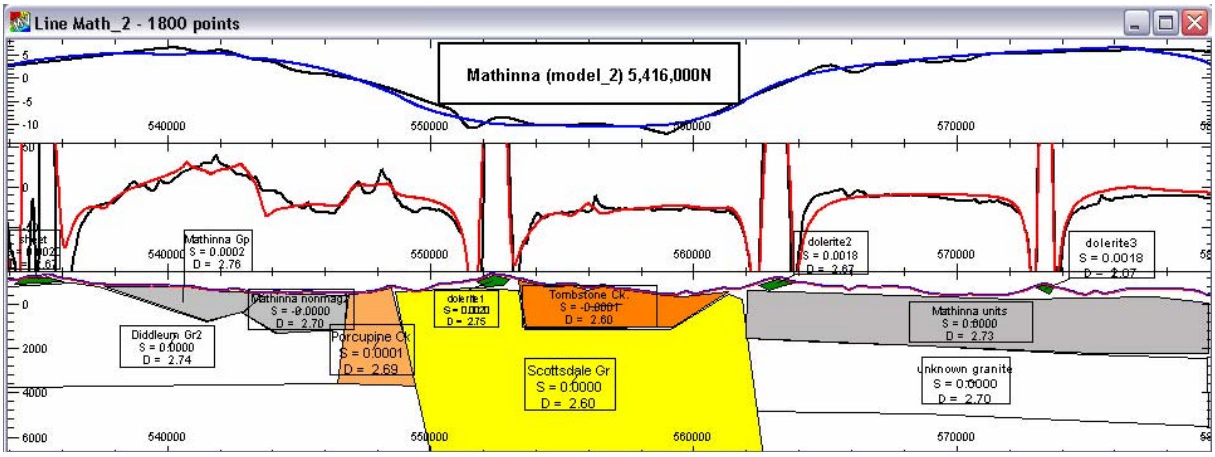

Figure 21. Model of TMI traverses 5,416,000N

The model for traverse 5,416,000N shows a distinct gravity low for the Scottsdale and Tombstone Creek granites that requires the latter to have a limited depth extent, implying it to be laccolithic in shape, however, the similarity in physical properties makes this difficult to prove. In contrast, the flanking Porcupine Creek intrusive is also magnetic and the model of the combined responses indicates it to be limited to 4km in thickness.

To the west of these granites, the gravity high is due to the combined effect of the Diddleum granite and the Mathinna units and though the physical property ambiguity makes it difficult to resolve the disposition of the two, the increased magnetic response for the Mathinna units suggests that the Diddleum granite underlies a thin wedge of the Mathinna units. To the east, of the granite the magnetic response is low and the gravity high is again modelled to reflect an unknown granite at depth rather than locally increase the thickness of Mathinna units and conform to the other model traverses.

The third traverse (line 5,423,000N) is shown in figure 22 has a similar profile to the above lines and the model is in agreement, with the exception of the Pyengana granite. This intrusive has a higher susceptibility (k = 0.0004 SI) and erratic pattern due to topographic relief.

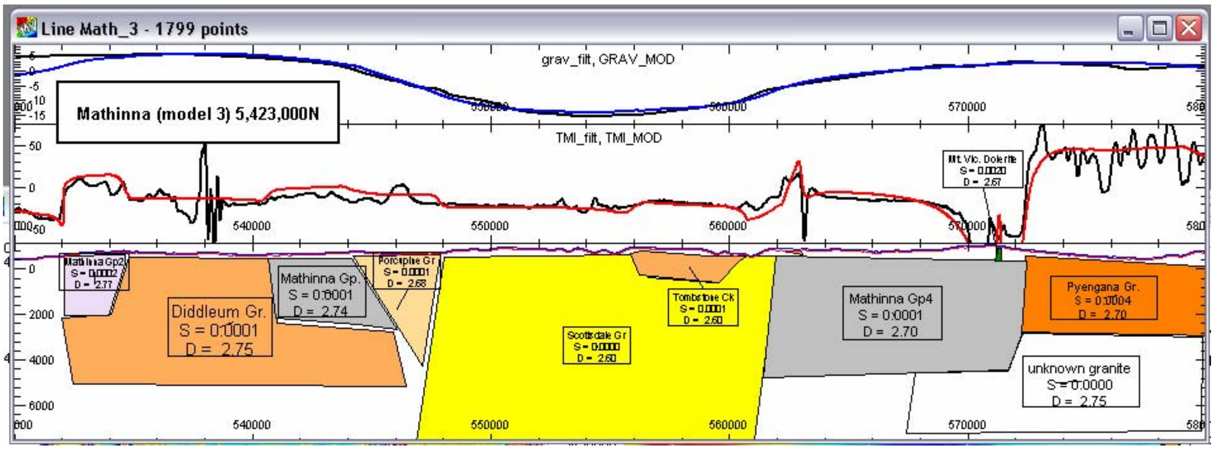

Figure 22. Model TMI and gravity profile for line 5,423,000N

The fourth traverse (line 5,430,000N) is located within the magnetic influence of the deep ultramafic and must be modelled using the unfiltered magnetic and gravity data and will be a direct comparison of the new magnetic data with the model results of Roach for the central portion of virtually the same line (NE3 at 5,428,000N). Figure 23 shows the data and model for this traverse and the regional gravity gradient is modelled by inclusion of the east dipping Cambro-Ordovician sediments and Precambrian metasediments contrasting with the low density Blue Tier granite in the east. The presence of these deep, high density lithologies must provide a prime contribution to the lateral extent of this gravity gradient rather than just the contribution of individual granitoids.

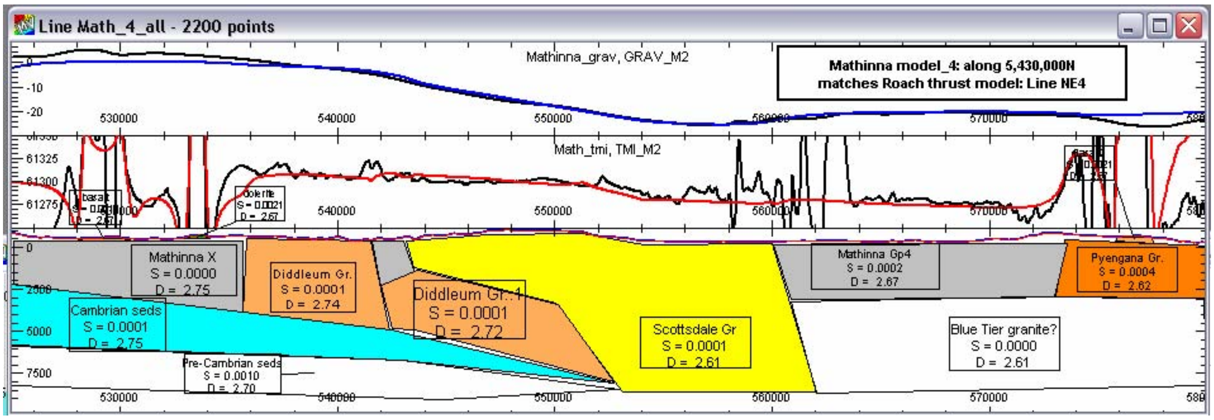

Figure 23. TMI and gravity model for traverse 5,430,000N

6. Implications for gold mineralisation

The high resolution magnetic data have assisted to define a geophysical signature for gold deposits within the Mathinna Super Group units. These include:

- The magnetic grain of the Mathinna units is broadly attenuated along the NNW gold corridor from Alberton to Mathinna, and supported in a detail 1VD image, especially in the vicinity of maximum grouping of gold mineralisation localities.

- The 'gold corridor' through Mathinna trends along the length of a significant 'residual' gravity high that is interpreted to reflect an unknown granitoid that may be the source of the mineralisation under structural control.

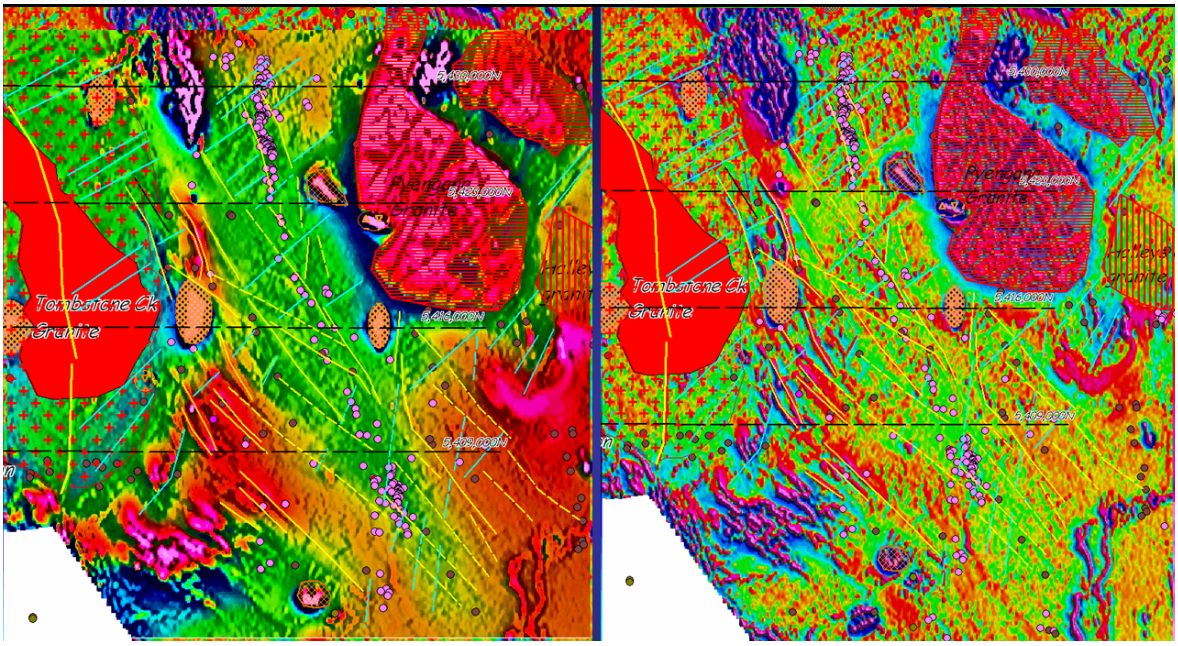

Figure 24. Enhanced TMI images showing interpreted fracture pattern and gold deposits

The residual TMI with 1VD as shade image (Fig 24) shows a broad, reduced magnetic response (approximately -20nT over 5km width) for Mathinna units along the NNW gold corridor. Detail of the colour 1VD image shows NNW trending linears, conforming with mapped foliation in Mathinna Supergroup units, and NE trending features reflecting faults and dykes, eg in the Scottsdale Granite. The combination of these features suggests a complex fracture pattern that may be related to the location of gold deposits.

Thus for the Alberton to Mathinna 'gold corridor' it is proposed that the reduction in magnetic response for the Mathinna units together with the presence of an unexplained residual gravity high combines to give a signature that may be used in gold exploration.

The broader gravity picture (Fig 5b) shows that other goldfields, or clusters of gold occurrences, are associated with residual gravity highs, eg Lisle, Lefroy & Lyndhurst, some of which are interpreted to be granite related and thus support the concept of a generalised geophysical signature.

7. Conclusions

Bridport models of deep ultramafic:
Magnetic and gravity models, using the 2007 data set, of the deep magnetic anomaly near Bridport support the Roach (1994) interpretation of a deep ultramafic unit.

The modification of Seymour (2007) for an uplifted wedge of the ultramafic, due to faulting, can also be supported. However, a significant portion of the local anomaly is due to shallow basaltic(?) sources.

An alternate model suggests the local magnetic anomalies are due to a magnetic alteration aureole in Mathinna units related to intrusion of the Diddleum Granite.

A fault almost certainly trends north to south, with offsets due to NW-SE structures within the Mathinna Supergroup, and this structure could be associated with the source of extrusive basalt.

Northern Scottsdale granite
The northern Scottsdale granite is either relatively thin (2 – 2.5 km) or of higher density than to the south and is flanked by a magnetic aureole in the Mathinna units on each side.

A linear gravity high (trending NNW) is caused by Mathinna units wedged between the Blue Tier and Scottsdale granites. The variable gravity profile is interpreted to be due to alteration caused by granite (perhaps Blue Tier) beneath the Mathinna units

A linear magnetic feature (trending NNE) through the Mathinna units is located at the contact of the higher density, and is probably a dyke that is observed to be offset from the Scottsdale/Mathinna contact to the south.

The eastern contact of the Mathinna units with the Blue Tier granite is a slightly magnetic aureole or dyke, similar to that to the west.

Models of the Mathinna Super Group:
The magnetic and gravity signature of granitoids and meta-sediments is best defined after removal of regional gradients due to deep seated geology. The distribution of shallow geology can be modelled using the filtered data then compared with the original data to re-introduce the response of the deeper features.

Roach (1994) noted that the Mathinna area is underlain by low density granitoids and that the Mathinna Group rocks vary from 1km thick in the North to 3km thick in the South. These parameters were maintained for this study and physical properties were also of the same order as those compiled by Roach.

The Mathinna units were noted to have increased susceptibility in the near vicinity of granitoids and increased magnetic response can be taken as indicating shallow granite. For example, on southern lines, the Dilldeum Granite is interpreted to continue to the south, beyond outcrop, and increase the magnetic response of the Mathinna units.

A broad zone of reduced magnetic response in the vicinity of the gold corridor, is modelled as reduced susceptibility in the Mathinna units, as also noted by Roach.

A broad gravity high in the east is assumed to be due to deep granitoid (non-magnetic but with higher density, so could be reduced I-type), which could be the source of alteration causing magnetic depletion in Mathinna units and perhaps related to the source of gold mineralisation.

Implications for gold mineralisation

The TMI with 1VD as shade image shows a broad, lower magnetic response (-20nT over 5km width) in Mathinna units along the N-S gold corridor. Detail of a colour 1VD image shows NNW trending linears, conforming with mapped foliation in Mathinna Supergroup units, and NE trending features reflecting faults and dykes, eg in the Scottsdale Gr.

The magnetic grain of the Mathinna units is broadly attenuated along the NNW gold corridor, and in detail, especially in the vicinity of maximum grouping of gold mineralisation localities.

The 'gold corridor' from Alberton - Mathinna trends along the length of a significant 'residual' gravity high that is interpreted to reflect an unknown granitoid that may be the source of the mineralisation under structural control.

The broader gravity picture shows other gold clusters/goldfields are associated with residual gravity highs, eg Lisle, Lefroy & Lyndhurst, some of which are granite related.

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