LEAMAN GEOPHYSICS
Registered office:
ABN: 34 479 871 658
3 MALUKA STREET, BELLERIVE, TAS. 7018
All correspondence to:
GPO Box 320, HOBART, TAS. 7001
Telephone: (03) 6244 1233
Fax: (03) 6244 6674

SUBSURFACE FORM OF GRANITES EASTERN TASMANIA Preliminary interpretation 2010

Analysis for KUTh Energy

by

D. E. Leaman

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SUMMARY

A preliminary interpretation of subsurface form of the roof of East Tasmanian granitoids is offered based on current gravity data sets and use of the most recent regional-residual separation (2009). The interpretation has been termed preliminary since it is based on simple modelling of gravity data alone and this has yet to be integrated into a refined whole for eastern Tasmania (currently in preparation for Mineral Resources Tasmania – MRT – using 3D tests and adjustments). When that project is complete it will be possible to provide a more detailed and, probably, much more reliable view of the granites. This caveat must be noted when assessing comments offered here. The interpretation might also benefit from an equivalent magnetic study (to resolve and separate shallow sources as well as variations in batholith composition) but available magnetic data lack the regional reliability and consistent integration of observation and compilation which would make this possible for the entire tenement.

The present study is, however, most suggestive in terms of batholith distribution and character and, therefore, represents – due to improvement (2010) in data density east of Campbell Town – a significant change from earlier interpretations (whether for MRT or KUTh – Leaman *et al* (1980), Leaman & Richardson (1992), Leaman, (2007).
There remains much scope for further gravity analysis as noted above but this should be combined with other methods, including perhaps some drill intersections, since simple density contrast assumptions for basement/Mathinna Beds or batholiths/granitoids are clearly not satisfactory and extended interpretation might allow a more complete rendering of granitoid variations or sequence changes (as implied by Leaman, 2008).

INTRODUCTION

KUTh Energy holds an exploration licence (see Figure 9) across a large part of eastern Tasmania for the evaluation of the potential for deep geothermal sources and anomalous heat flows.

Quite apart from general geothermal gradients which can lead to temperatures in excess of 250 ^{o}C at modest depths (3 to 5 km) beneath continental Tasmania there is potential for abnormal gradients and conditions related to some granitoids and other structures. There is, consequently, considerable interest in the location and disposition of granitoids at depth since this distribution may prove critical to industrial operation, scale and economics of any possible extraction of heat.

Several versions of interpretations of Tasmanian granite distribution at depth have been produced since about 1975 but most analysis has been directed toward the granites of western and northern Tasmania. This situation reflects both distribution of gravity data, essential for the analysis, and previous economic imperatives. Existing models presented by Leaman *et al* (1980) and Leaman & Richardson (1992) covering the east Tasmanian batholith were incorporated into the 2002-2004 (Leaman & Richardson, 2003) compilations by Mineral Resources Tasmania with the caution that "as further data is acquired the model may change significantly, particularly in the east and south-west."

Much data has been acquired since 1980, some in the eastern region (Sorell, MRT; Forestier Peninsula, Leaman, 1997). This had not been used to revise the model published in 2003 due to lack of priority and the persistence of poor coverage across a large part of the eastern highlands. Much of the gravity coverage of this region was based on an old helicopter survey and 7 km station spacings.
An infill survey by KUTh Energy, was completed in 2007 and this change was reported and interpreted by Leaman (2007). That infill led to a more reliable view of the granitoids but it was evident that large gaps in coverage persisted as did the need to re-assess the batholith in this eastern region. This has led to the present review which has also incorporated further infill by KUTh survey in the northern section of its tenement where EM-MT surveys had revealed some unexpected character. The new unfill, observed by Solo Geophysics of Adelaide using GPS control methods jn the first half of 2010, comprised about 400 stations with location precision better than 20 cm, claimed elevation better than 4 cm, with observed gravity better than 0.02 mgal, and this was terrain corrected to a 20 km radius.
The EM results, and initial heat flow determinations, apparently inconsistent with the 2007 interpretation (Figure 3), which drove this accretion are shown in Figures 1 and 2.

DISCUSSION

An interpretation of large granitoids can be generated from a detailed study of the gravity data but this requires complex models which include crustal and oceanic components and much detail of other anomalous sources. An alternative approach is to filter the data in order to remove long wavelength effects due to crust and ocean sources (including water) and then examine the gross features which remain. Since large granitic bodies and batholiths generate very large anomalies the negative features of moderate scale can be separated without need to include elements of fine structure and stratigraphy – most of which is unknown and must also be inferred in this region.
The filtering process can be undertaken in many ways but the most reliable is a model which can replicate the very long wavelength features as an equivalent source (Roach *et al*, 1993).

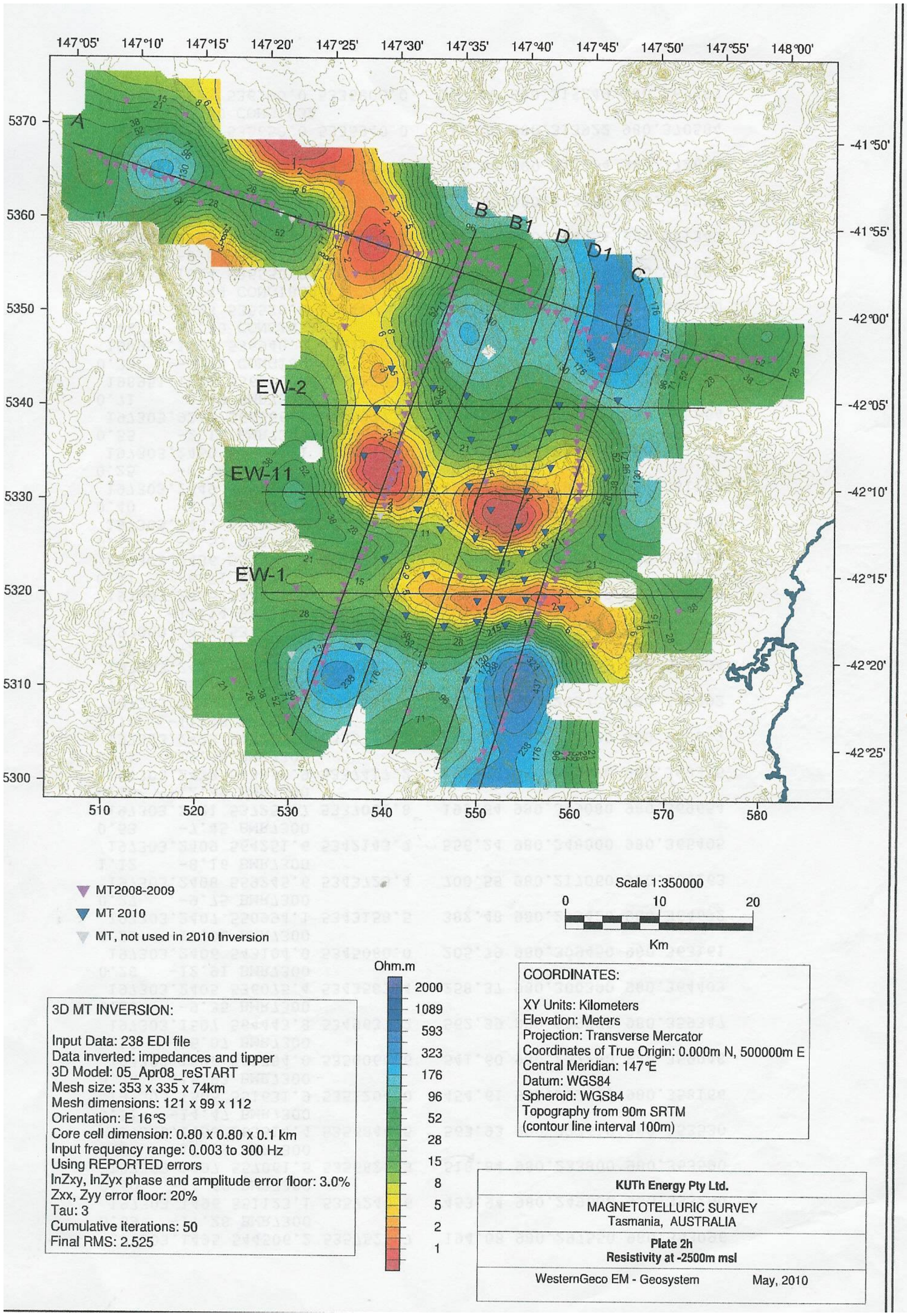


Figure 1: EM-MT (source KUTh Energy)

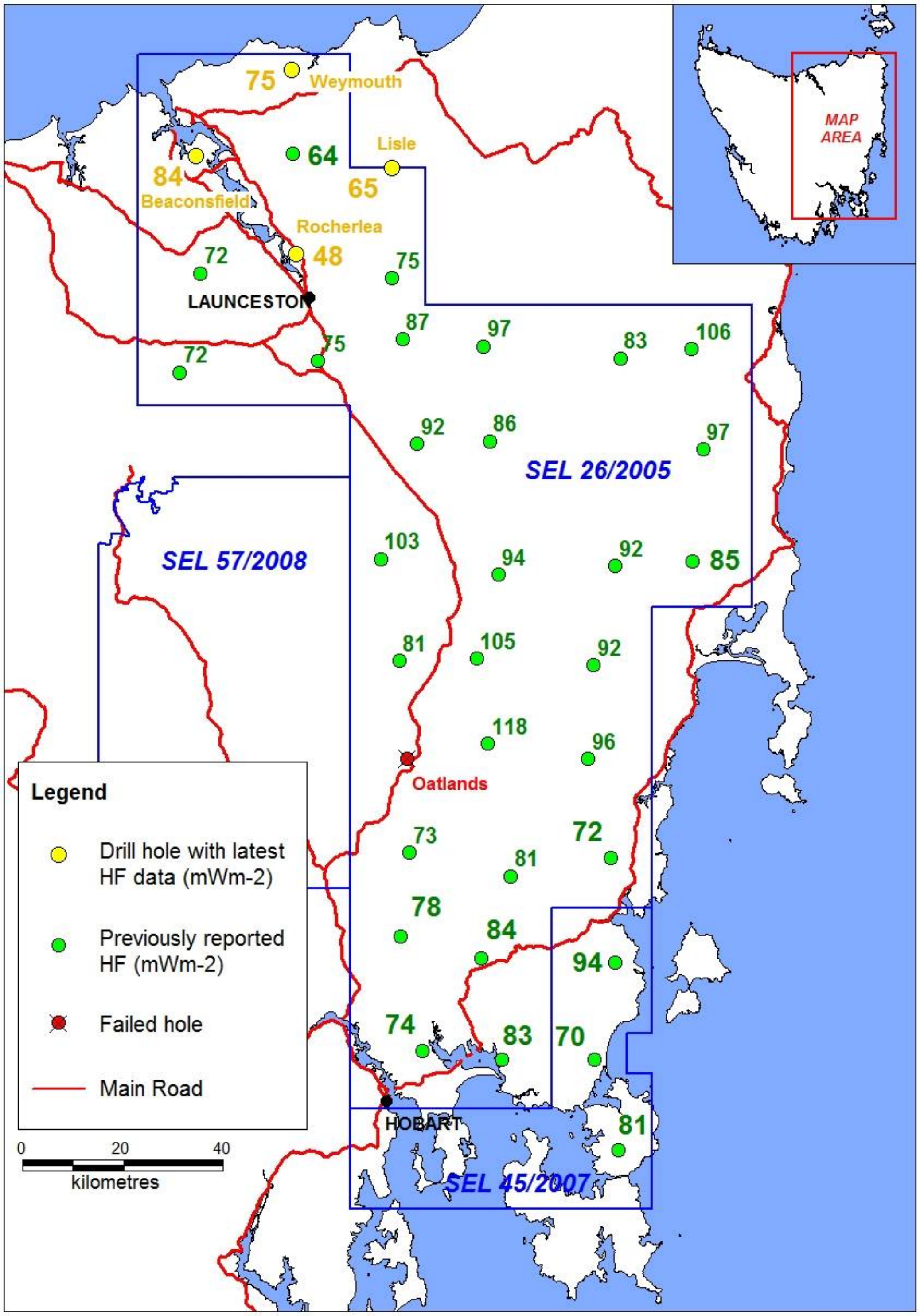


Figure 2: Heat flow data as at May 2009 (source –KUTh Energy)

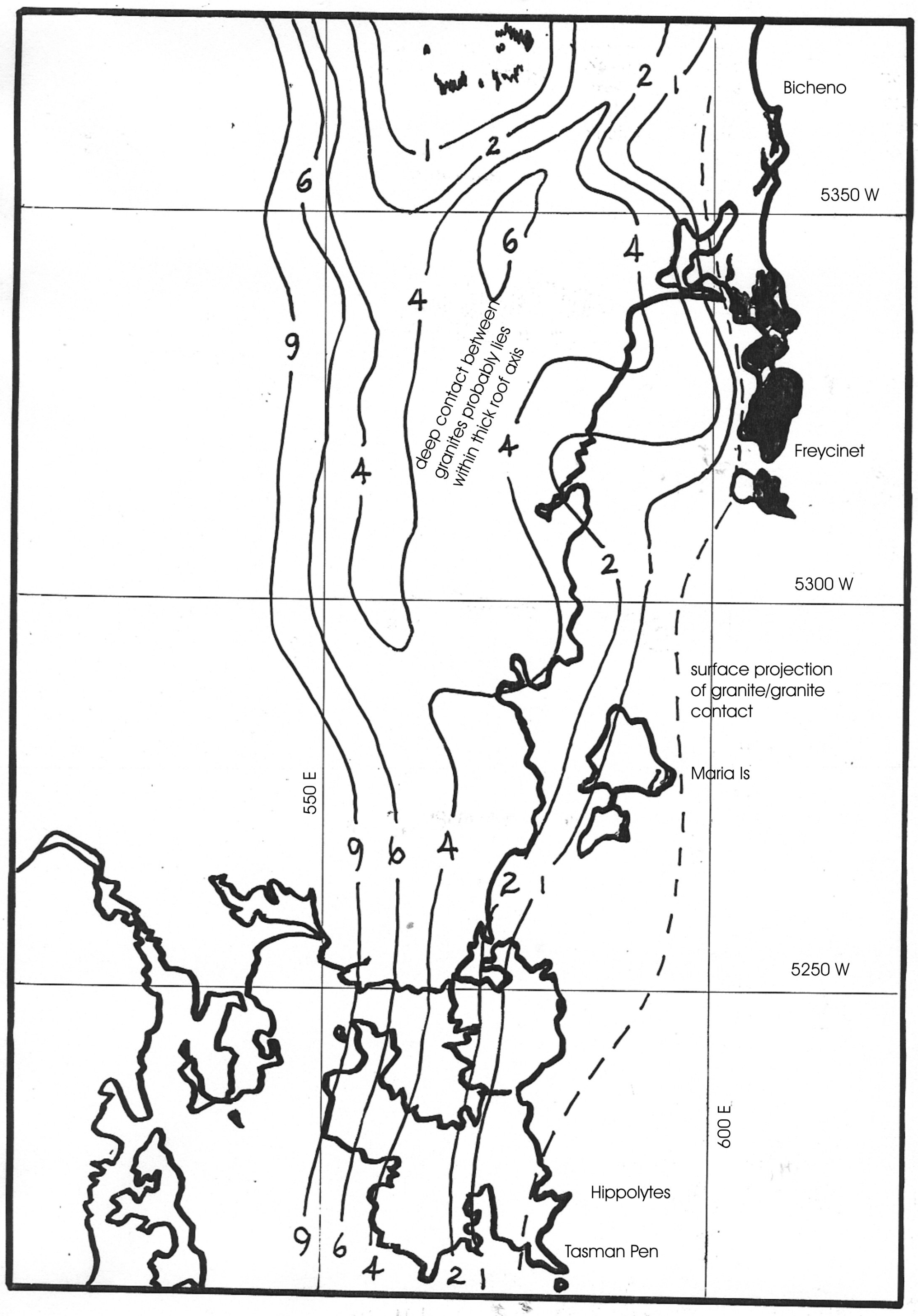


Figure 3: Granitoid model – October 2007- depth to granite surface in km.

Such an equivalent source model was developed by Leaman & Richardson (1989) based on available seismic control for mantle limits and a large array of long modelled profiles in NW Tasmania. These profiles examined all large sources in the upper crust, as well as defining the overall form of the lower crust. The lower crustal elements were combined into a three dimensional model which can generate the gross form of the gravity field across Tasmania and its adjacent ocean basins. This was known as MANTLE88.
Following a series of regional interpretations in western and northern Tasmania the model was refined and termed MANTLE91. This model was the basis for all interpretations until 2007 when a new separation was developed for MRT (MANTLE07). This was revised in 2009 (MANTLE09). This recently derived version, which has benefited from the data accretion from 1980 to 2008, including data in Eastern Tasmania, has been used to derive the residual field used for the present interpretation The new model displays has resulted in many changes – mainly in amplitude of negative anomalies: A comparison of the generated residuals may be seen in Figures 4, 5, 6.

Observed data contain substantial high frequency elements which are related to Jurassic dolerite (feeders, dykes, large multiple intrusions) and Tertiary structures (basins and sedimentary cover). Some attempt has been made to assess these features – especially the Tertiary cover – but much surface mapping and observation pf the dolerite is required before the contributions from this source can be properly appraised. Comprehensive analysis of magnetic data would assist but this has yet to be done.

Care has been taken not to over-interpret the data at this stage. With the exception of known granite exposures along the east coast (from Bicheno to the Hippolytes off Tasman Peninsula), and the concealed cupola immediately west of Bicheno and north of Llandaff, there is no control on the granite surface.

Further, any refined interpretation depends upon the constraints assumed and the nature of upper crustal contents and contrasts west of the batholith. On past experience that the batholith, en masse, has a general density of 2.59-2.62 t/m^3, and that the intruded upper section of the crust has an average density of about 2.74 t/m^3 the basic modelling can define the gross shape of the batholith. The intruded rocks are certainly correlates of the Mathinna Beds in the eastern part of the region but may be complexes including portions of the west Tasmania terrane elsewhere. Either package could yield the bulk density inferred.
It should also be commented that bulking of densities may mislead and conceal some important realities. Each batholith in the region (Scottsdale, Blue Tier) consists of several plutons wide ranging in composition (granite, adamellite, porphyritic versions, diorite, granodiorite) and internal densities may range from 2.59 to 2.72 t/m^3. Similar variations may exist in the stacked, overthrust or detached intruded sequence depending on proportion of silica, arenite or argillite. This means that reduced or reversed contrasts may exist with important consequences for interpretation. This is thought to be most critical in terms of the Scottsdale Batholith and its possible southward extension since it appears to include a higher proportion of, denser, granodiorite.

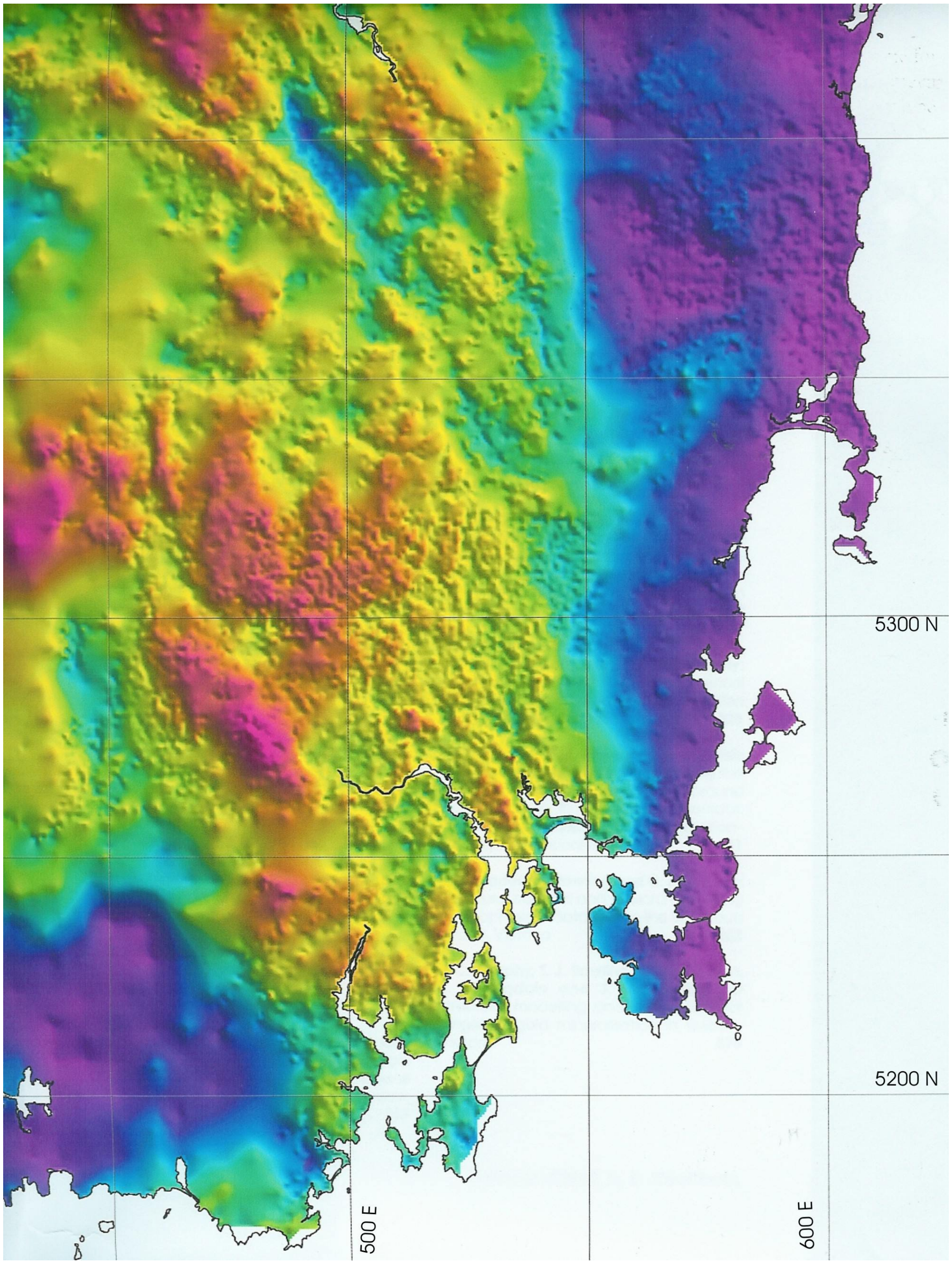


Figure 4: Residual Bouguer anomaly using MANTLE91 (source MRT)

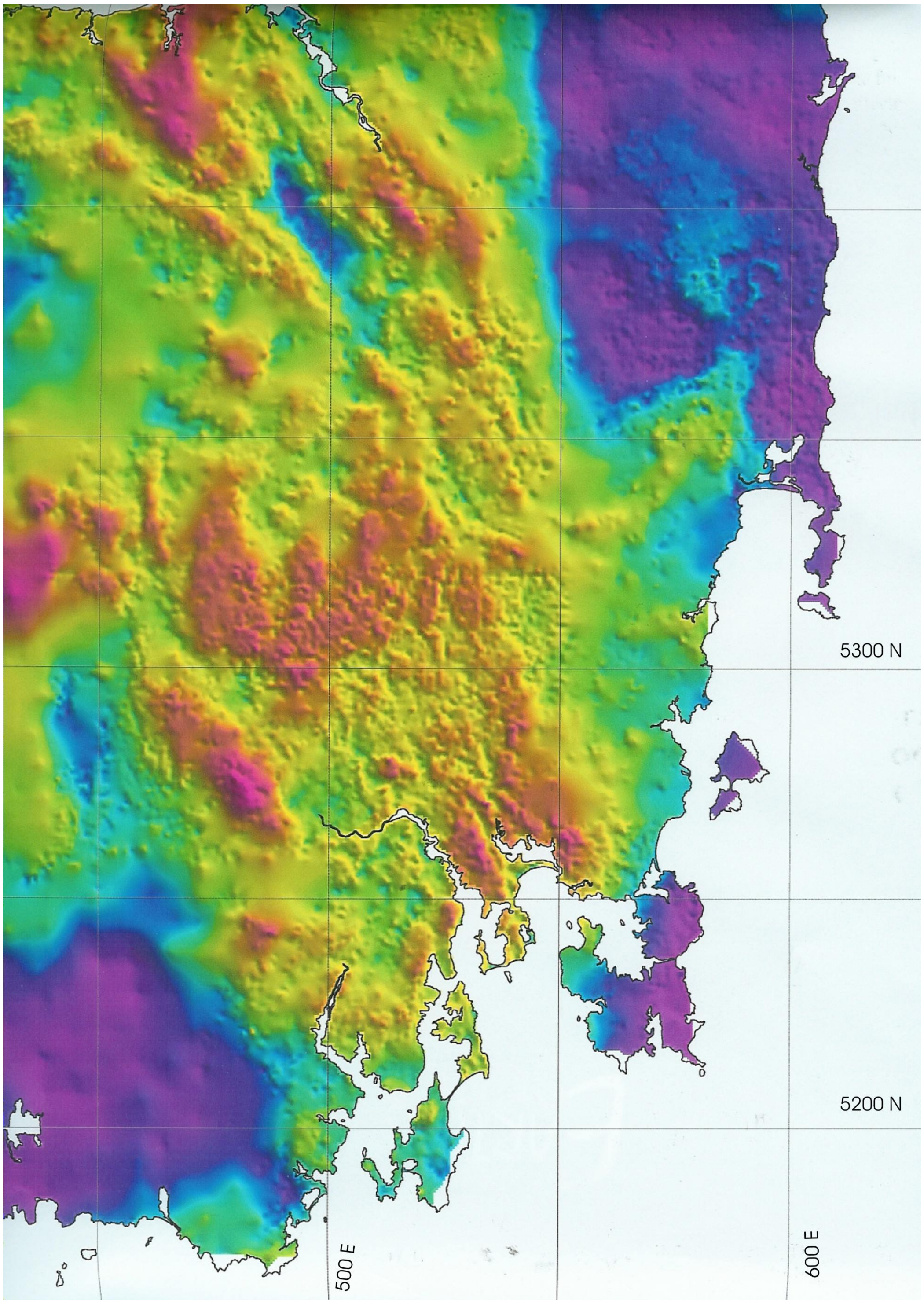


Figure 5: Residual Bouguer anomaly using MANTLE07 (source MRT)

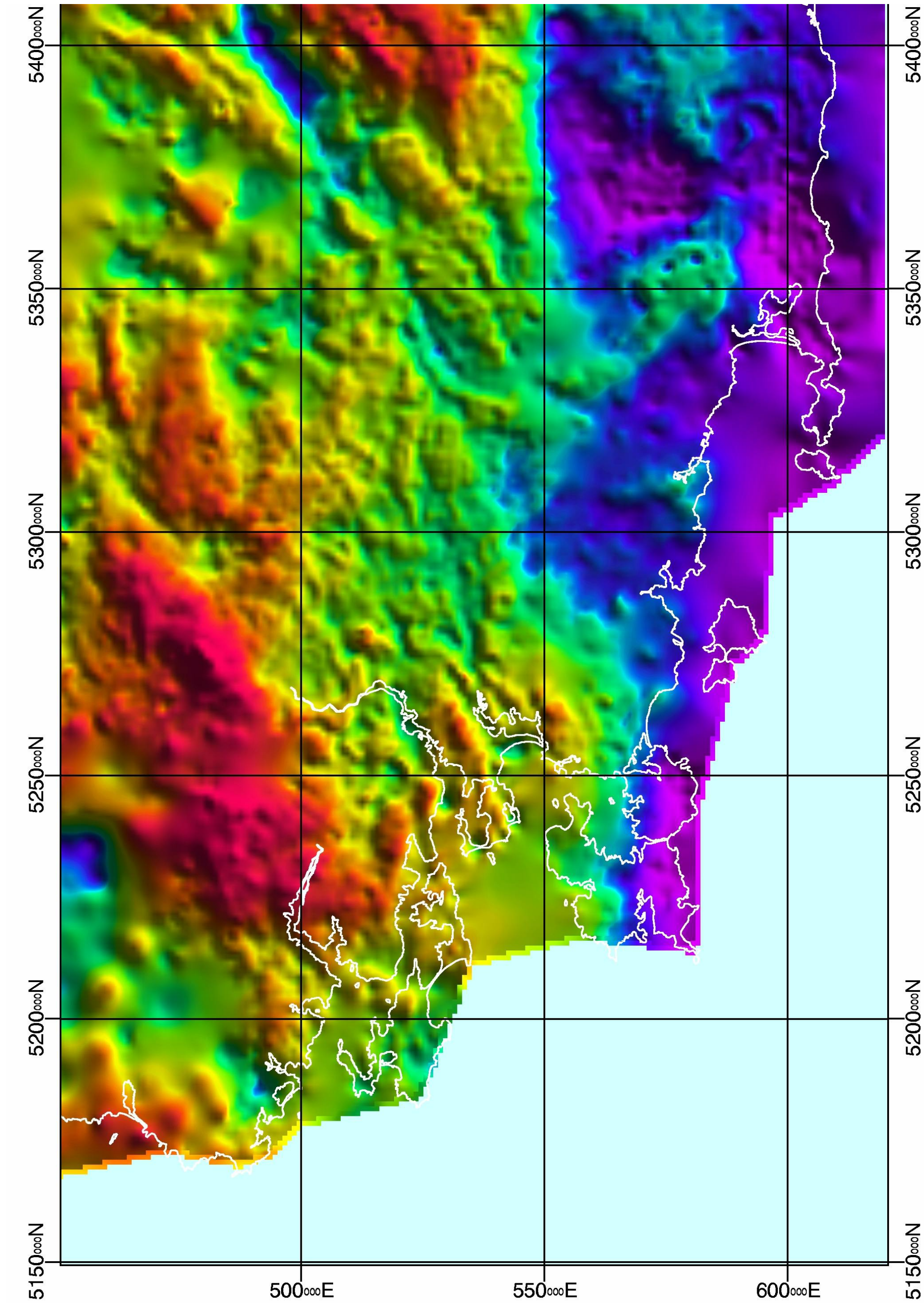


Figure 6: Bouguer anomaly using MANTLE09 (image source MRT)

As a result of problems with negativit of anomalies near the east coast, the 2007 interpretation (Figure 3) implied three batholiths south of the Avoca-Fingal-St Marys axis and two of these required bulk densities of 2.60 or 2.59t/m^3. While the actual values are possible for individual plutons they are not credible for the larger volumes of a batholith. Much more believable solutions nave been extracted from residuals based on MANTLE09 (see Figures 7 and 8).
Test modelling of the effect of variable contrasts, in both batholiths and roof cover rocks, suggests - using the 2D methods which are the basis of the present preliminary model – that a vertical ambiguity of up to 25% in implied vertical depth is possible locally but that the general shape of the roof is retained with a fair measure of reliability and consistency. Thus, the character of the new model can be accepted with the proviso that it be confirmed by 3D modelling. 3D checking has not been undertaken at this stage since the KUTh zone of interest is only part of a regional granitoid belt currently subject to project review by MRT, a project dependent on 3D refinement yet to be begun.

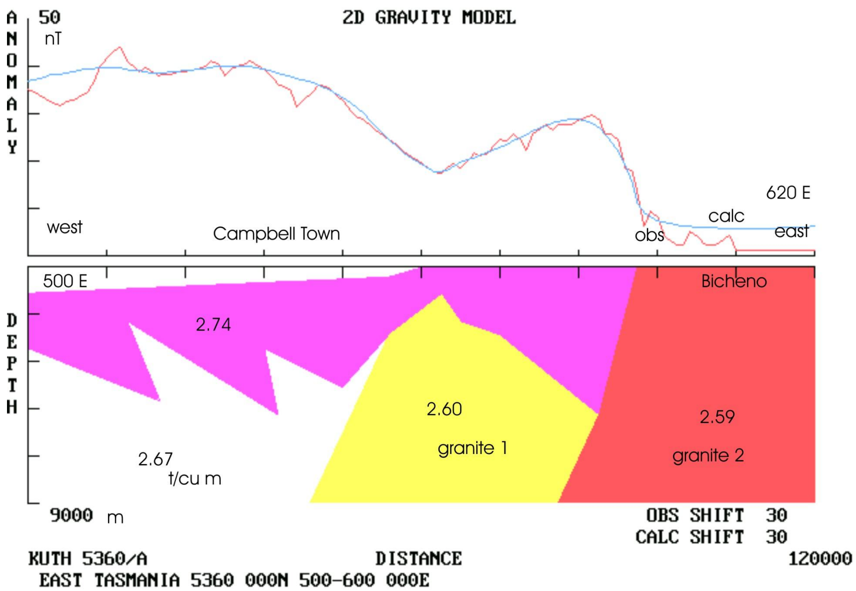
Figure 7 for line 5360 000mN (upper diagram) is typical of the type of solution that had been obtained in the northern part of the region, south of Royal George and west of Bicheno (see Leaman, 2007) and this may be compared with the new revised version (lower diagram).

The existence of granite exposures along the east coast limits many options for density contrasts and shows that the general crust cannot be wholly high density and that an interface must exist ; indeed, that the eastern batholith has been barely unroofed.
Detailed character in the observed anomalies is related to dolerite intrusions, Tertiary basins (especially at the western end west of Campbell Town), and related features.

The entire package of granites, here termed the batholith, cannot be explained with a single density unless one part of the body extends to greater depth. The problem of gradients and amplitude arise consistently down the coast irrespective of possible deficiencies in the data base and reflects the reality that several different granitoid compositions are in fact observed in each exposure locality (for example there are four variants at Deep Glen Bay on Forestier Peninsula and comparable behaviour is noted elsewhere).

The model wst of Campbell Town cannot reliably indicate whether Mathinna Beds equivalents extend to greater depth, or the granitoids reach shallower depths such that no discontinuity exists (like that implied. The contact between Scottsdale Batholith plutons and those of the Blue Tier Batholith is inferred to lie about 75 km along the section or no more than 50 km east of Campbell Town.
No detailed modelling of the rocks of the Tasmania Basin cover has been attempted.

Figure 8 presents a modelled section at 5275 000 N.
Similar comments apply to all aspects of the solution even though there are different anomaly patterns.



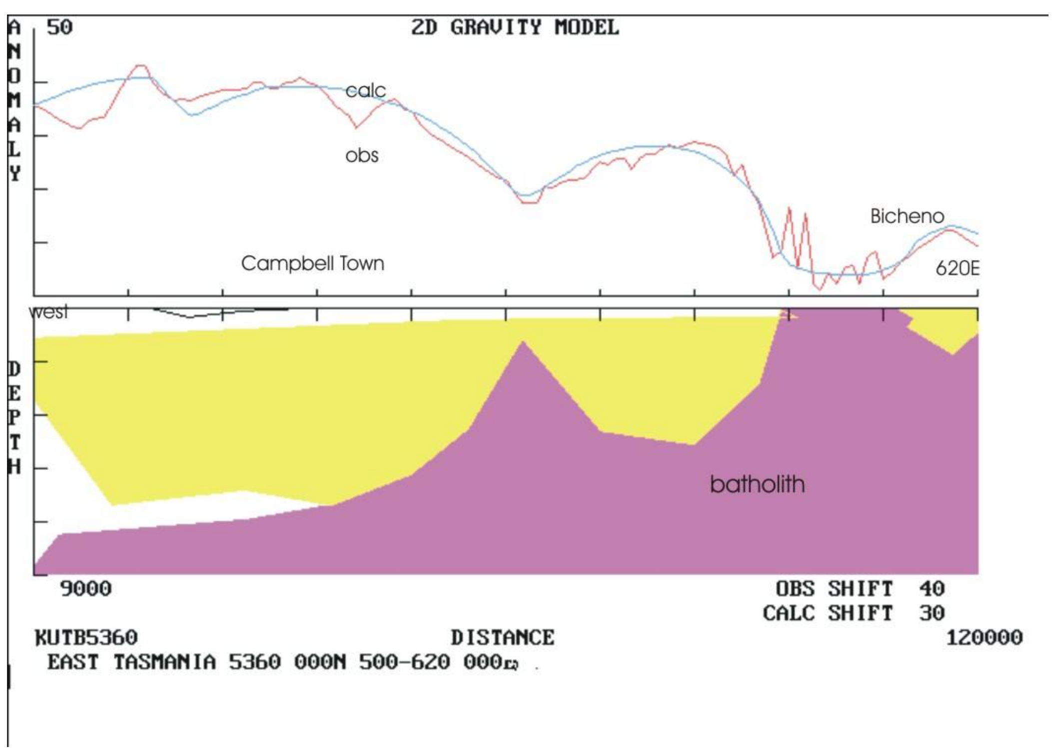


Figure 7: Model section at 5360 000 N, 500 000 – 620 000 E

The western half of the section reflects much shallow character – this profile is a transect of the Derwent and Coal rift systems with many Jurassicand Tertiary structures. The eastern half of the section is dominated by the underlying granites and the effect is onset between Runnymede and Buckland.

The broad, shelving gradient can be explained with the simple two intrusion batholith solution inferred elsewhere and this explanation should be preferred to the older solution given by Leaman & Richardson (1992) in which a marginal granodiorite was introduced, save to note that the western batholith or western part of the complex – a probable extension of the Scottsdale Batholith – is dominated by granodiorite.

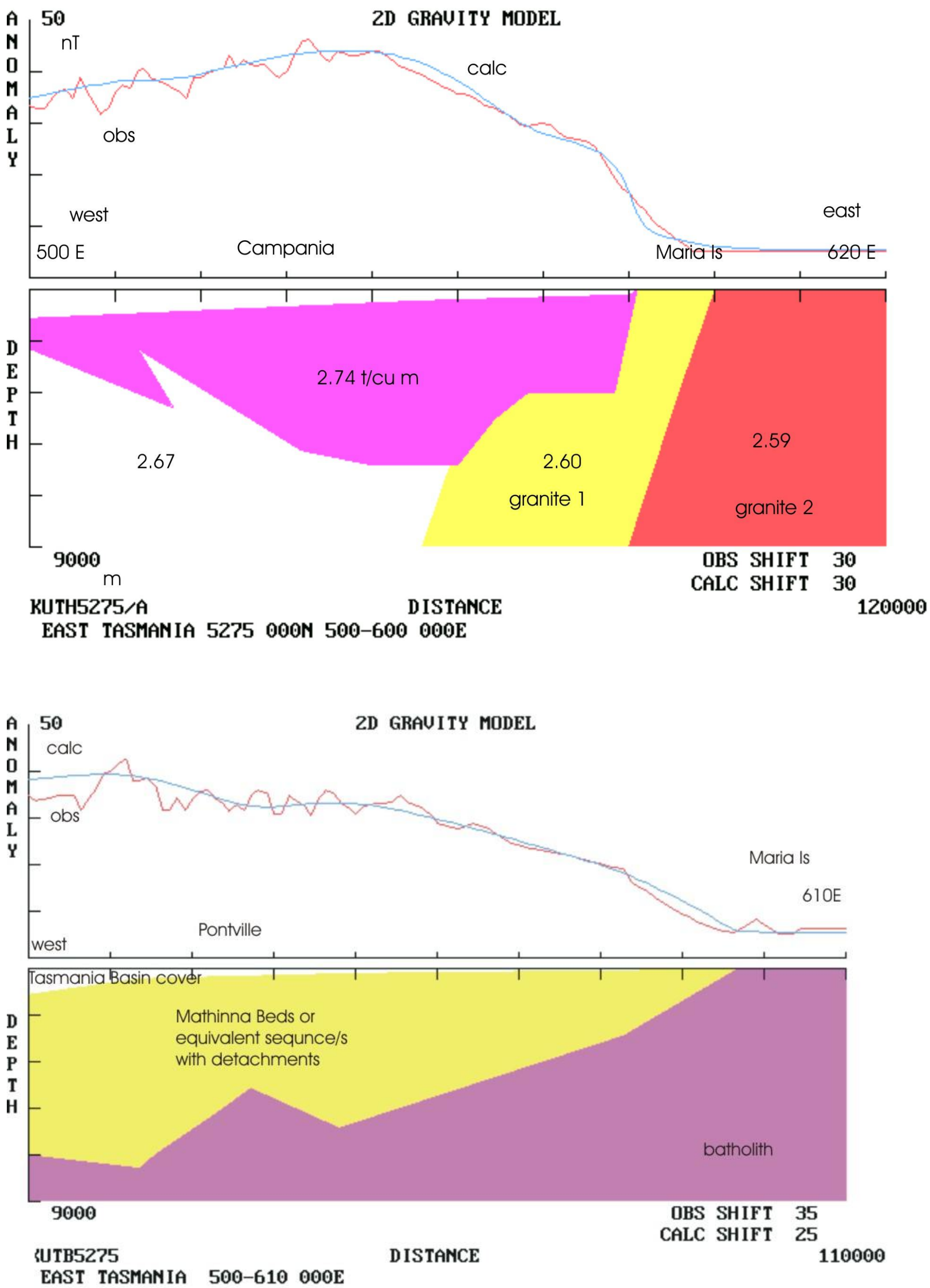


Figure 8: Model section at 5275 000 N, 500 000 – 620 000 E

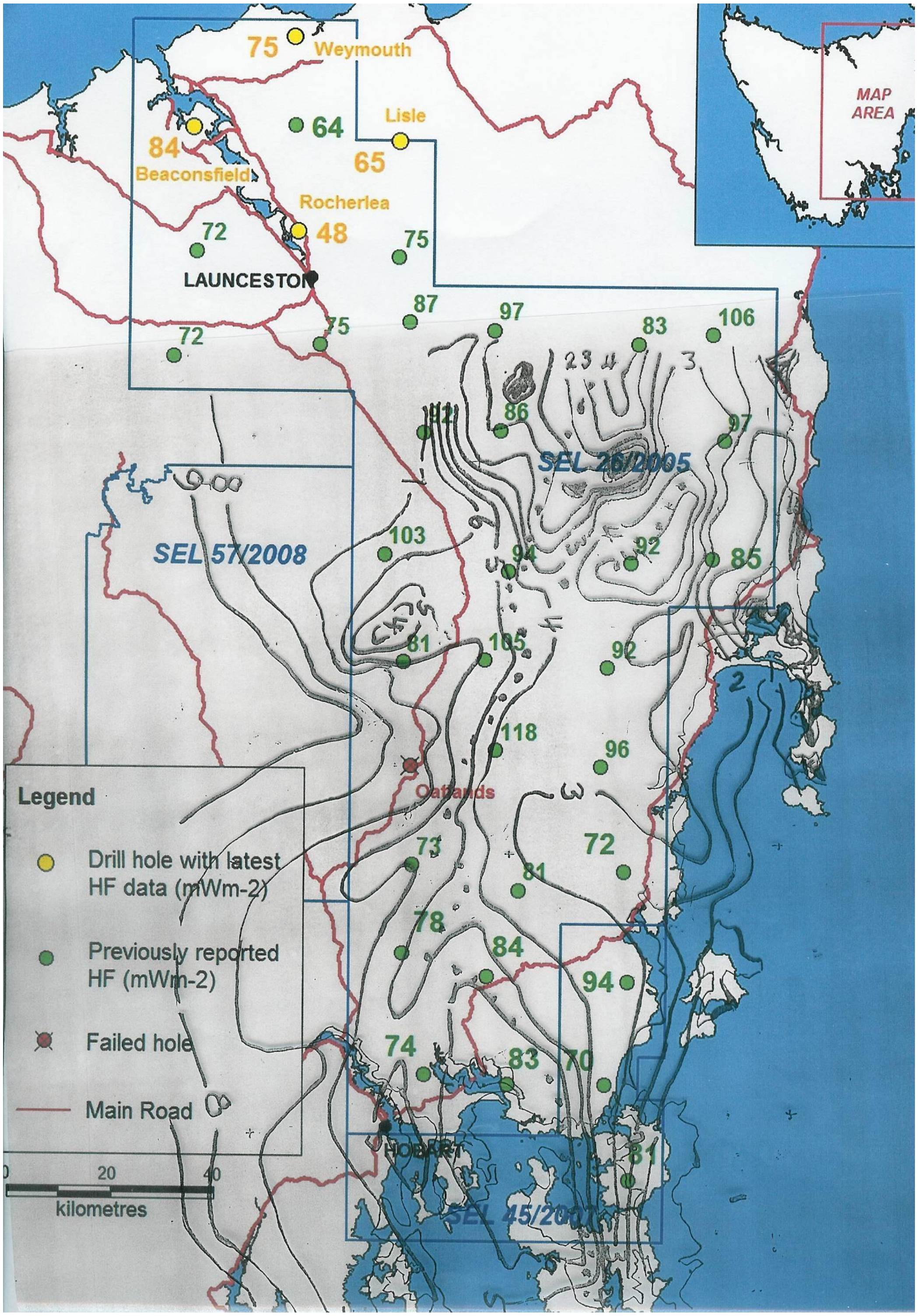


Figure 9: Heat flow determinations and new model

The probable reliability of the interpretation, summarised in Figures 9, 10, cannot be properly assessed in the absence of some control. The new granite model (Figures 9,

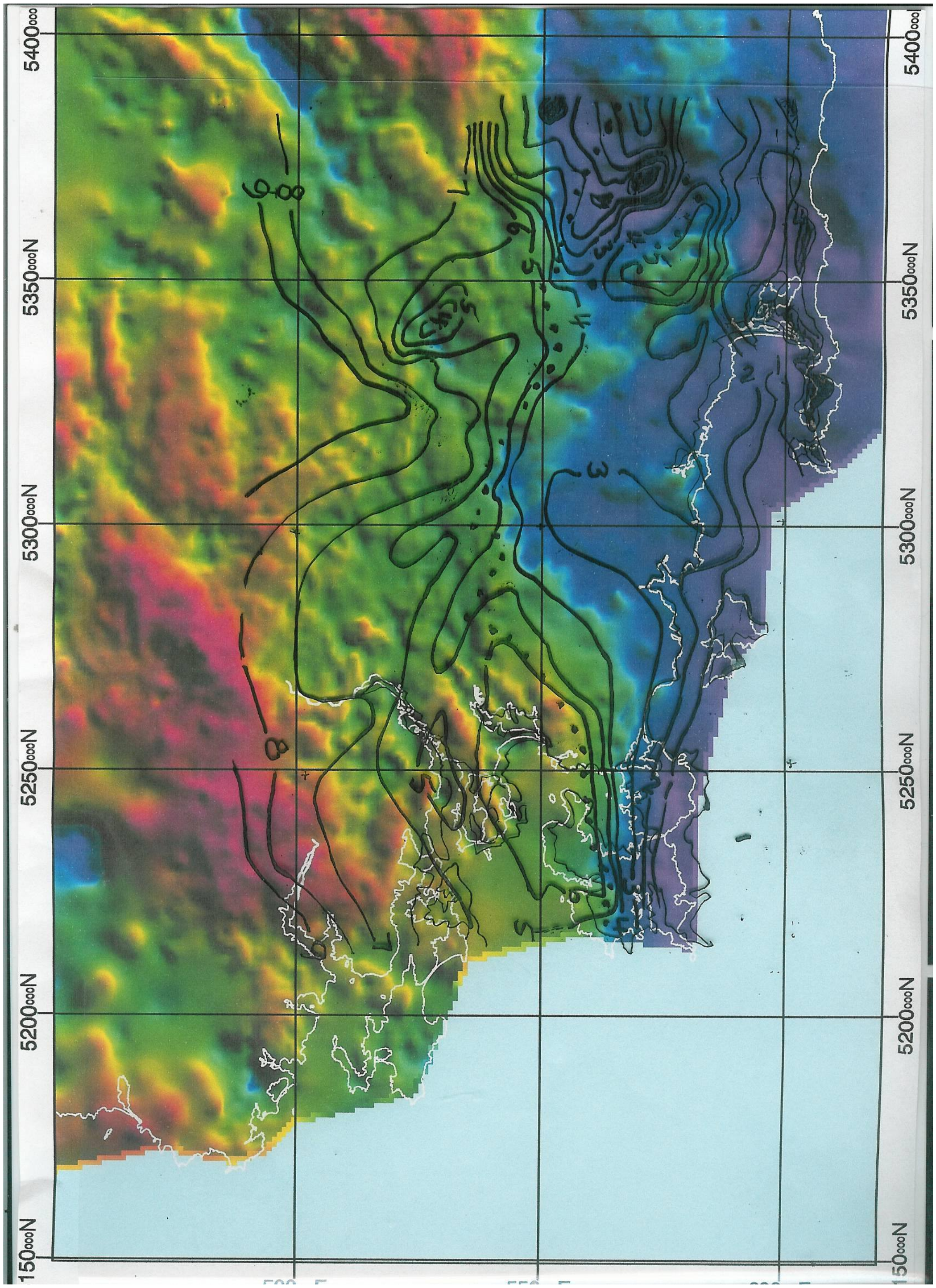


Figure 10: Residual Bouguer Anomaly (MANTLE09) and new granite model.

KUTh Energy acquired some detailed magnetic coverage in 2009 and images are displayed in Figures 11 and 12. Some heat flow data are superimposed in the interpretations offered in Figures 11 and 14. An initial interpretation prepared by KUTh Energy is included in Figure 11. This view emphasizes shallow, or relatively shallow, features.

Changes in trends suggest a deep-seated component is also involved in the structures and this is recognisable in both gravity data and the regional topography (shown in Figure 13). The ruling trend is, at crustal scale, ENE-WSW and a small, concentrated group of features bisects the island of Tasmania. The changes in local or shallowly-sourced trends have been emphasized in Figure 1 4 and most occur within the envelope of influence of the first-order structures. Elevated heat flows appear related to these structures or occur north of them. There is a difference between north and south Tasmania but any correlation with the new granitoid model is vague, at best.

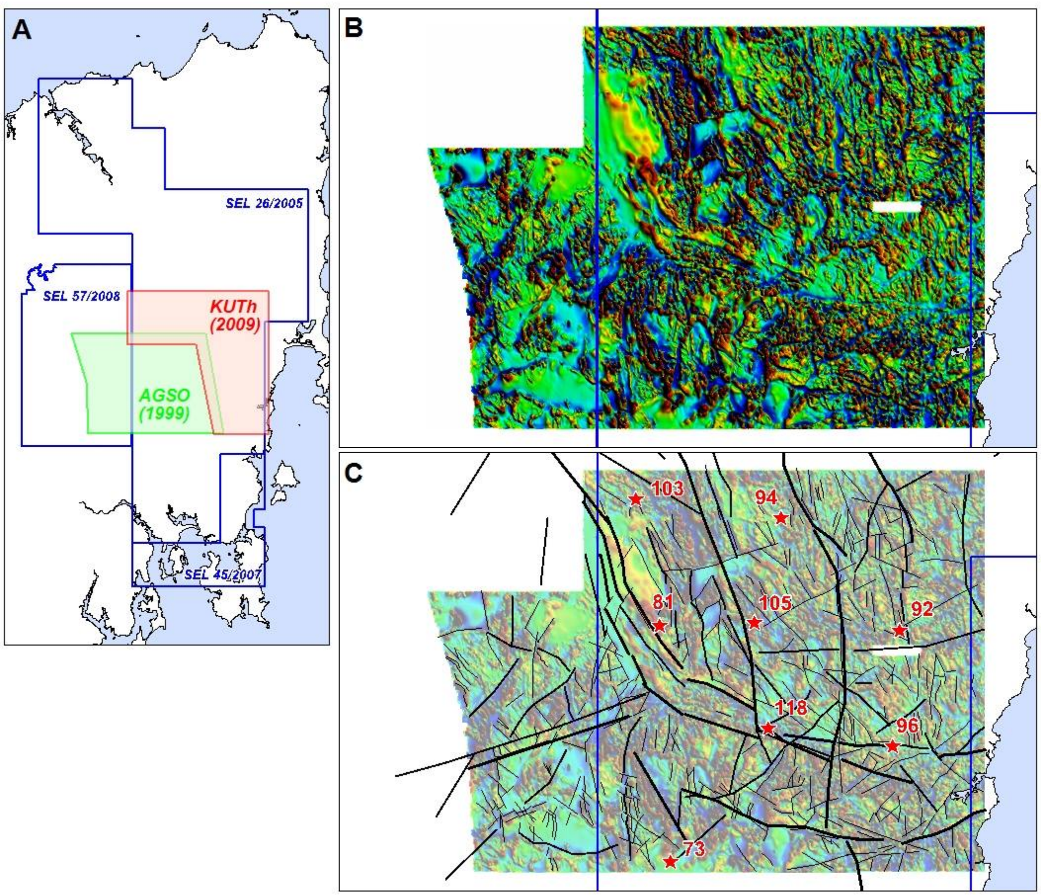


Figure 11: Location and interpretation of aeromagnetics – source kUTh Energy. Left- location of surveys, upper – survey reduction, lower – first interpretation with some heat flow values. Much of the magnetic character evident is associated with Jurassic dolerite and both Jurassic and Tertiary structures.

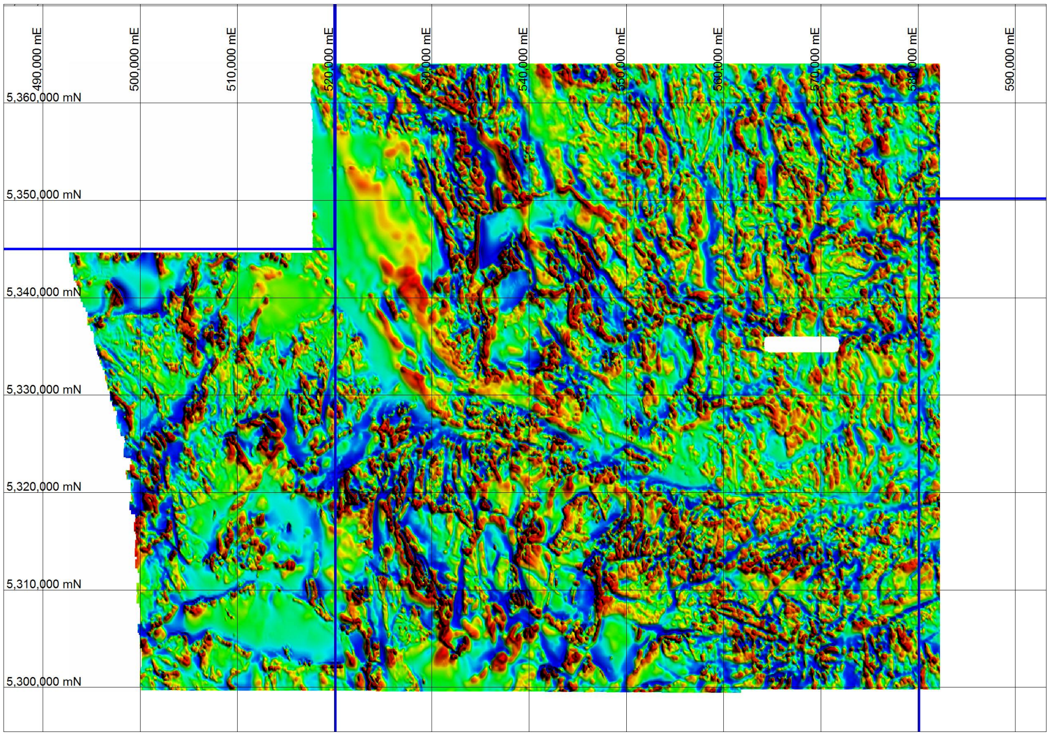


Figure 12: KUTh spliced compilation –aeromagnetics (source KUTh Energy)

Figur 14 displays an integrated, local magnetic survey compilation and over prints both the new granitoid model and some other trends not included in Figure 11. These tend to be consistent in orientation and location with elements noted topographically and gravimetrically which implies larger/crustal scale effects – within the envelope of such trends there are many lesser trend shifts and some of these have been marked with a circle. The alignment of such offset foci is also ENE. This is the type of effect produced by a perennially mobile stress crack in a plaster wall overlaid by wall paper, more plaster and paint in which en-echelon shears, uplifts, ridges and twists result.

These characteristics are taken to imply thaat the entire region, in geological terms, remains structurally active and that the fracture system may be held in stress and be at least partly open, to fluids.

This conclusion may have important consequences for the KUTh project and might also account for the heat flow distribution north and south of this zone.

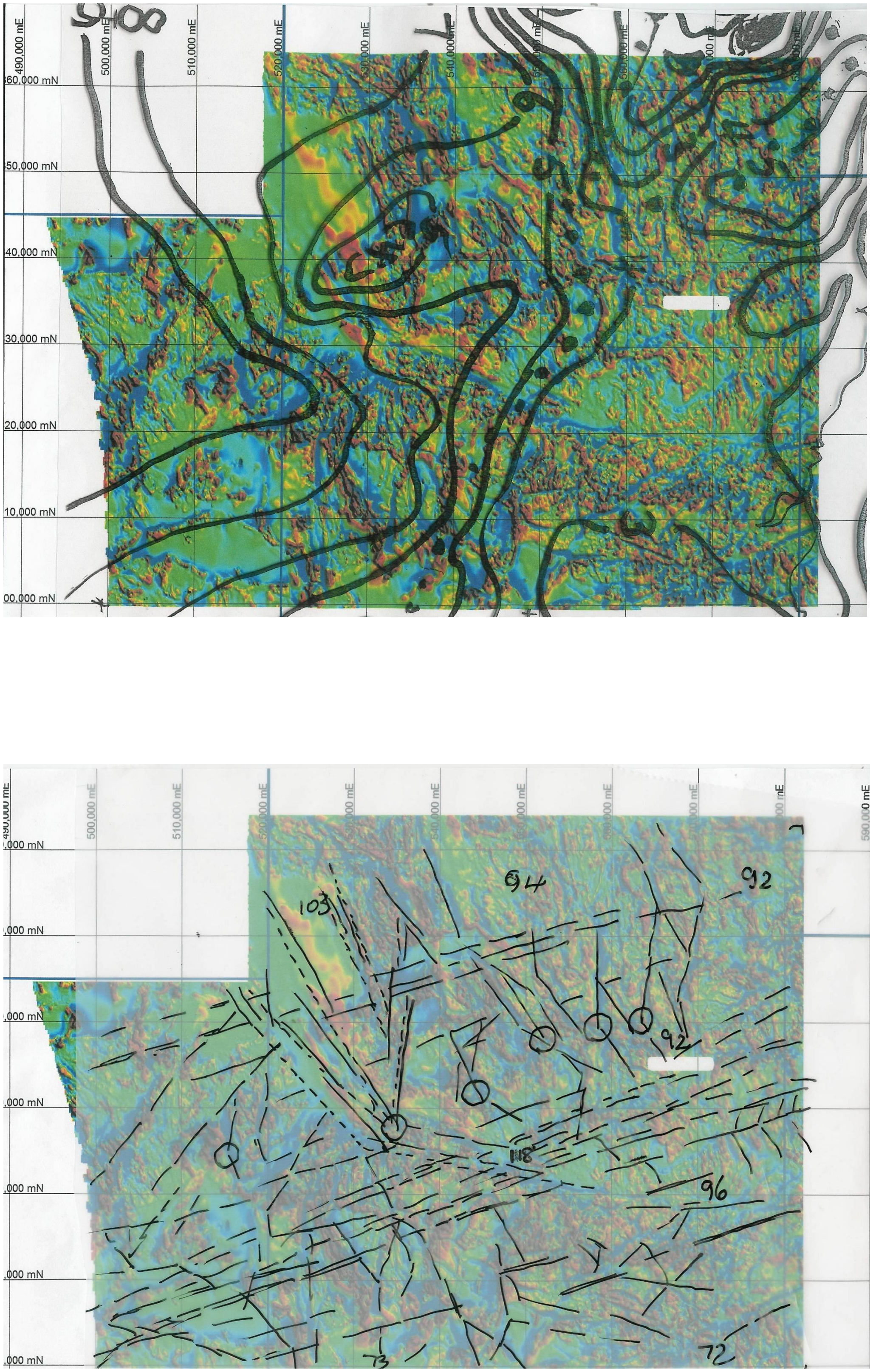


Figure 14: KUTh magnetics, heat flow and a regional trend interpretation.

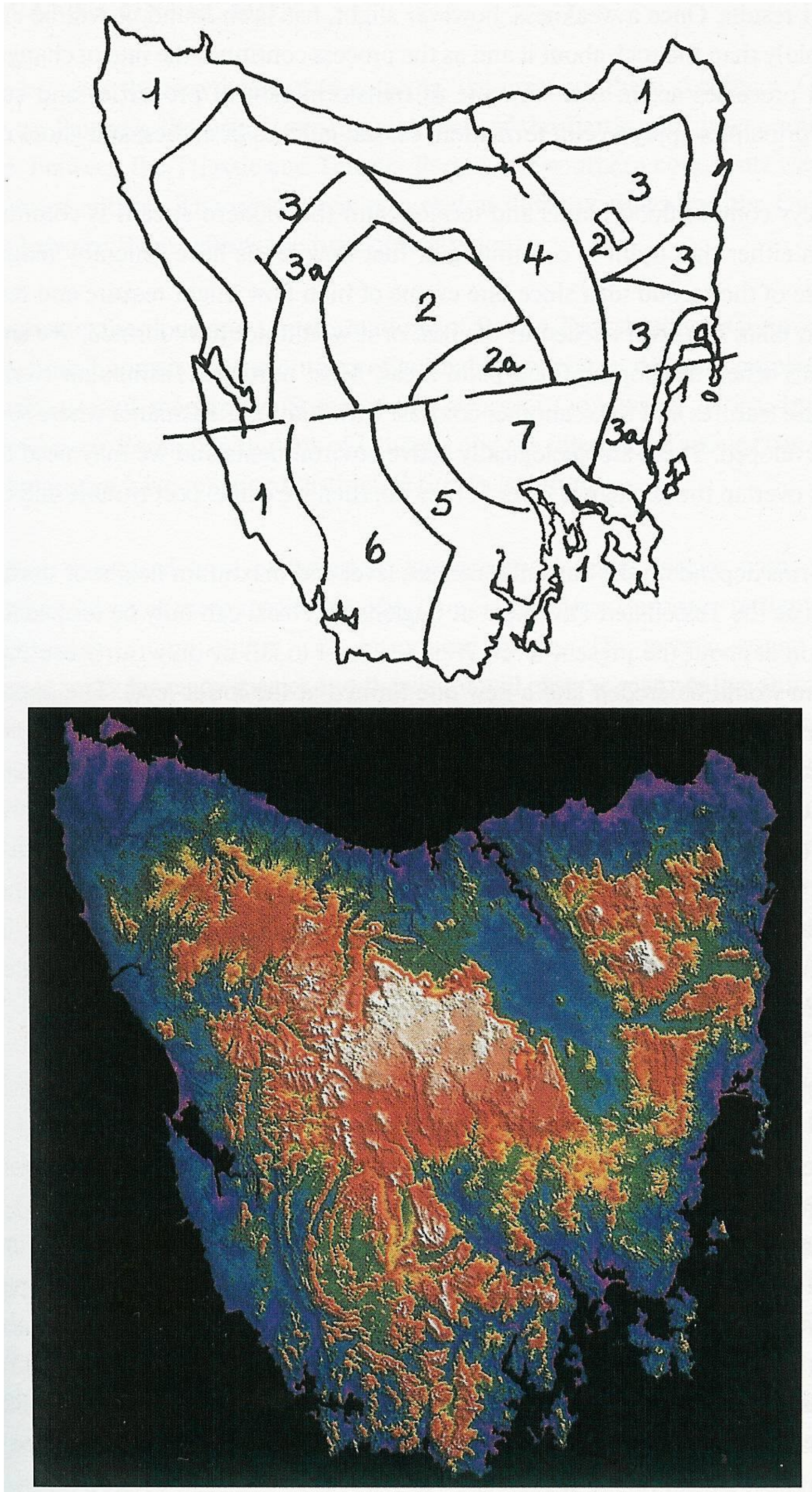


Figure 13: Topographic image of Tasmania (courtesy MRT) with interpretation from Leaman(2001)

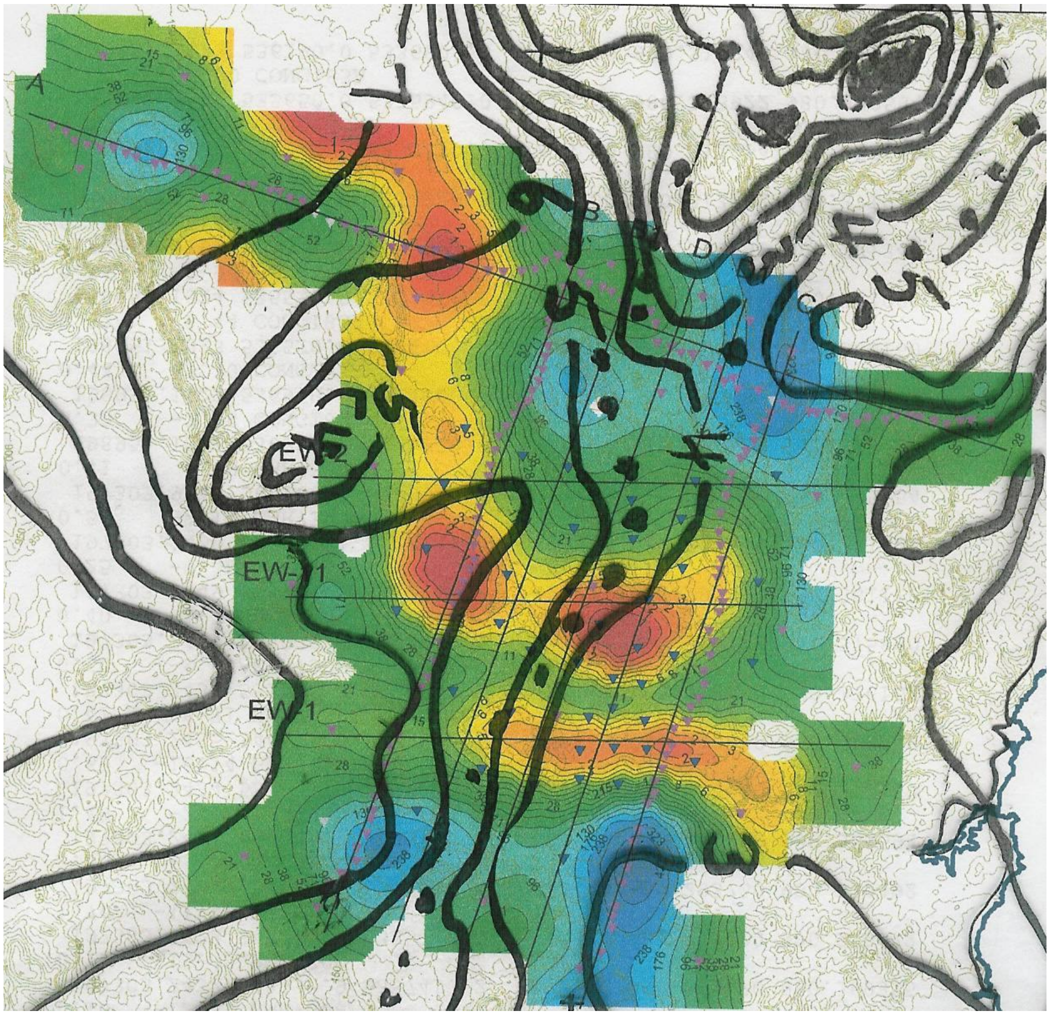


Figure 15: EM-MT and granite model.

The offset between the shape of the granite surface (even allowing for depth uncertainty) - and heat flow/conductivity suggests that the origin of conductivity variations – and perhaps heat flows as well – is due to structures in the intruded rocks or local plutons in the batholiths.

The previously inferred simple, linear western margin of the batholith complex is denied and shown to be disrupted by, or partly controlled by, a major sub E-W break. Instead, it is implied that the two batholith complexes exposed in NE Tasmania. The heavy dotted line shown in Figures 9, 10 and 14 is suggested as the likely contact between the Scottsdale and Blue Tier batholiths.

The present interpretation should be reviewed again after the following conditions, all or part, have been fulfilled.

1. Offshore data must be fully incorporated into the State data base and consistently terrain-corrected.

2. Additional data are required on Freycinet Peninsula, Maria Island, Tasman Peninsula – and offshore island if possible.
3. Some drill control at locations where the granite surface is at depths in excess of 2 km.

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Report submitted on behalf of Leaman Geophysics by

Dr. D. E. Leaman   September 7, 2010

The current "simple" model subject to 3D revision: depth to granitoids in km; dotted line marks inferred location of Scottsdale/Blue Tier Batholith interface.