SEL26/2005

Annual Report Year 2

July 2008

APPENDIX 1

Report by Dr D Leaman on gravity survey and distribution of granites in south-eastern Tasmania

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

Analysis for KUTh Energy

by

D. E. Leaman

October 2007

INTRODUCTION

KUTh Energy holds an exploration licence 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. 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 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 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 2002 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, and the need to assess the batholith in this region, has led to the present review. The KUTh survey, observed by Solo Geophysics of Adelaide using GPS control methods, comprised about 500 stations with location precision better than 20 cm, elevation better than 4 cm, observed gravity better than 0.02 mgal, and was terrain corrected to a 20 km radius.

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).

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. It has been in use ever since and has formed the basis of most local interpretations.

Gravity data acquired since 1991 have been accumulated into the Tasmanian gravity data base but there has been no revision of the crustal model in order to make full use of it. Consequently, with additional surveys in central and eastern Tasmania and a requirement to review the granitoids, the crustal model has been reviewed and refined using the same specifications and methods of the original.

In order to do this a series of long (at least 300 km) profiles was randomly selected across the region south and east of the northern tip of Great Lake on the Central Plateau. The fan of lines covers the entire region south of St Marys in eastern Tasmania and South Cape in southern Tasmania. The original density constraints, the seismic ties, and fitting specifications were sustained so that the new or revised quadrant would remain consistent with the remainder of the model. The modelling led to some significant changes in crustal profile and also identified some minor errors and deficiencies in the ocean part of the model. The new model, now termed MANTLE07, thus represents a significant update. A minor change was made to the static shift which allows the best general fit to all data: to 389 mgal, vs 388 mgal, based on an implied range of 388-390 mgal (see also Leaman, 1988).

The new crustal model has been applied to the gravity data base and the result is shown in Figure 2. This may be compared with use of the older separation model (Figure 1).
The new residual anomalies have then been used to estimate the shape and depth of the eastern batholith and thus review the model published by Leaman & Richardson (1992) and incorporated in all recent compilations.

A series of east-west profiles was modelled south of 5375 000 N in order to test the general form of the intrusions since gross negative gradients run approximately north-south.

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

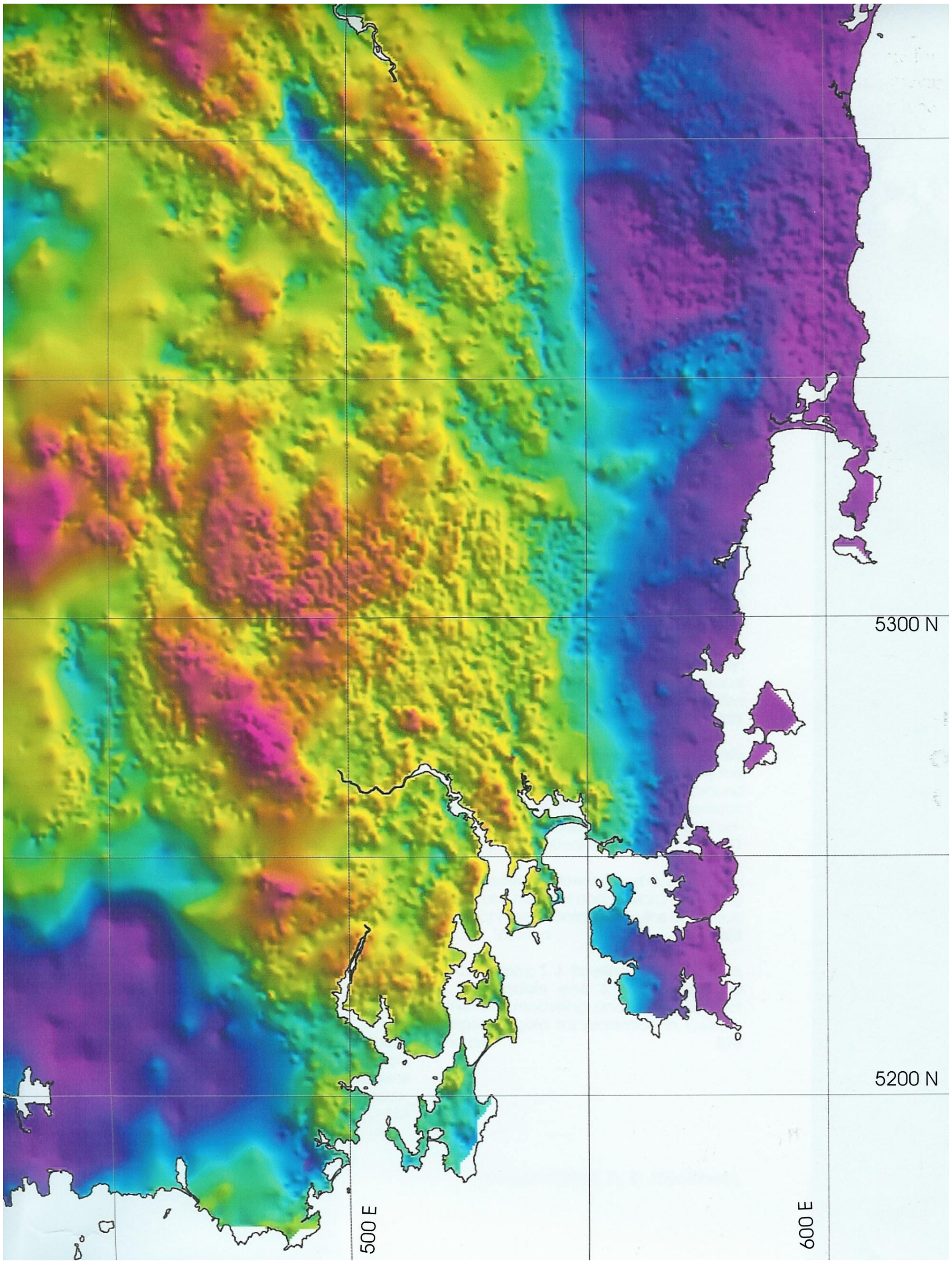

Figure 1: Residual Bouguer anomaly using MANTLE91

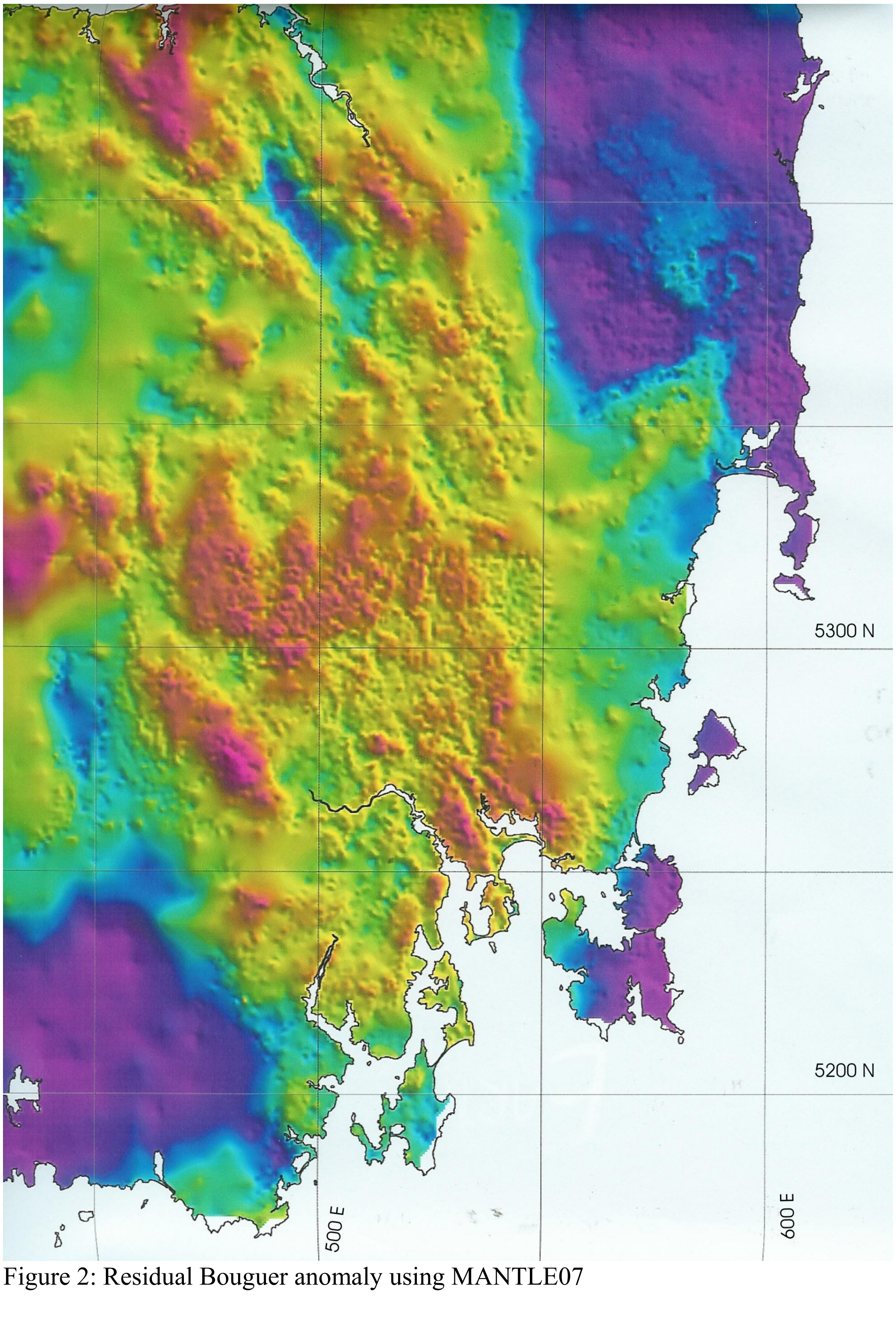

Figure 2: Residual Bouguer anomaly using MANTLE07

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.

Figure 3 is typical of the type of solution obtained in the northern part of the region, south of Royal George and west of Bicheno.

The existence of granite exposures in the east limits many options for density contrasts and shows that the general crust cannot be wholly high density and that an interface must exist. This is consistent with knowledge further north where the eastern terrane is overthrust on older Precambrian rocks. The irregularities of the overthrust terrane is crudely based on limited magnetic data and the inferred location of thrusts and ultramafics.
Detailed character in the observed anomalies is related to dolerite intrusions, Tertiary basins (especially at the western end), 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 (imperfect terrain correction of data across the continental margin) or the model separation process. This fact tends to suggest that the difference is real.

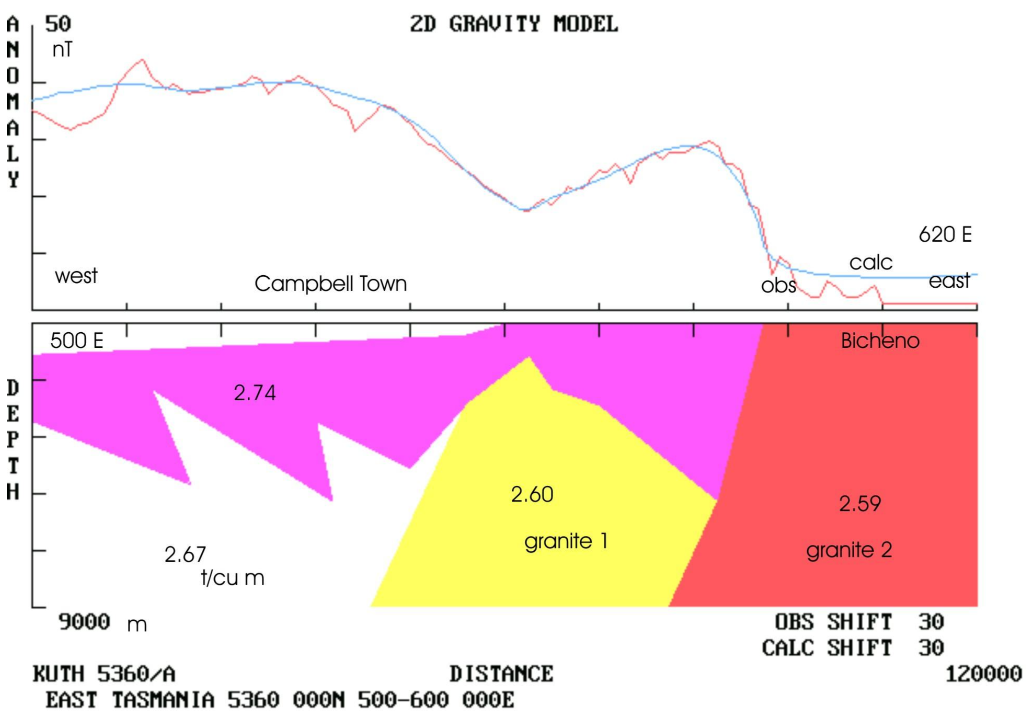

Figure 3: Model section at 5360 000 N, 500 000 – 620 000 E

Figure 4 presents a modelled section at 5275 000 N.
Similar comments apply to all aspects of the solution even though there are different anomaly patterns. The western half of the section reflects much shallow character – this profile is a transect of the Derwent and Coal rift systems with many Jurassic and 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. There is no evidence for this in the present analysis – which, of course, does not exclude it: rather it is an un-necessary and unjustified complication.

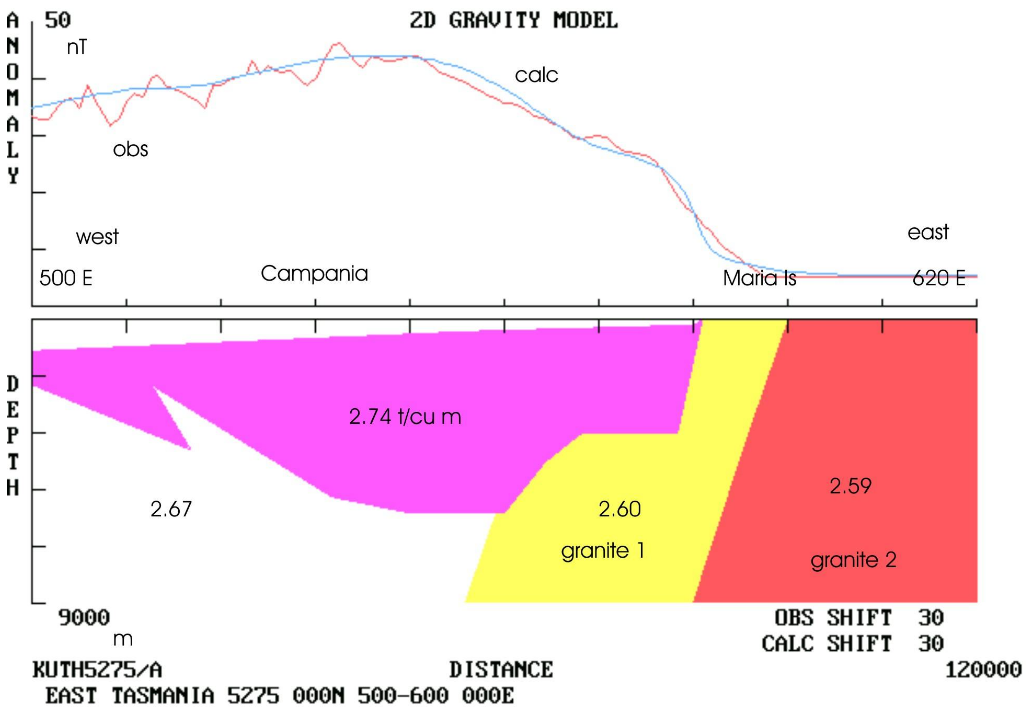

Figure 4: Model section at 5275 000 N, 500 000 – 620 000 E

The probable reliability of the interpretation, summarised in Figure 5, cannot be properly assessed in the absence of some control but a 1 km depth error is possible in those zones where depth to granite exceeds 4 to 5 km. Greater reliability, resulting from better gradient definition, is likely at shallower depths.

The new granite model (Figure 5), regardless of the above limitations, retains some elements of previous models, but with some important variations.

The essentially linear western margin of the batholith complex is retained, even though it is not as immediately obvious in the residual compilation (compare Figures 1 and 2). It is, however, markedly deeper and more shallowly shelving south of Avoca.

There is apparently a rib, extending to modest depths, just east of the margin in the central zone – south of Royal George and Avoca. A central block contains roof rocks up to 6 km thick south of Fingal Tier. The eastern side of the complex, near the coast, contains much steeper contacts.

The data, in the absence of any control, cannot be used to resolve differences in granite composition south of 5380 000 N onshore. Using the offshore extensions of the data, however, and the small segments of data on Freycinet and Tasman Peninsulas, and Maria Island, there is a suggestion of gross compositional change south of Coles Bay. This is indicated in Figure 5.

The present interpretation should be reviewed 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.
4. General additional survey upgrades to a general spacing of less than 2 km

REFERENCES

Leaman, D.E., 1988. MANTLE88. Regional gravity field, Tasmania. *Geophys. Rep. Mt Read Volcanics Project Tasm.* 8.

Leaman, D.E., 1997. Gravity survey and structure of the Forestier Peninsula, southern Tasmania. *Pap. Proc. Roy. Soc. Tasm.,* 131, 77-84.

Leaman, D.E. & Richardson, R.G., 1989. Production of a residual gravity field map for Tasmania and some implications. *Explor. Geophys.,* 20, 181-184.

Leaman, D.E. & Richardson, R.G., 1992. A geophysical model of the major Tasmanian granitoids. *MRT unpub. rep.,* 1992/11.

Leaman, D.E., Richardson, R.G & Shirley, J.E., 1980. Tasmania – the gravity field and its interpretation. *Unpub. Rep. Dep. Mines Tasm.* 1980/36

Roach, M.J., Leaman, D.E. & Richardson, R.G., 1993. A comparison of Regional-Residual Separation Techniques for Gravity Surveys. *Explor. Geophys.*, 24, 779-784.

Report submitted on behalf of Leaman Geophysics by

Dr. D. E. Leaman October 11, 2007

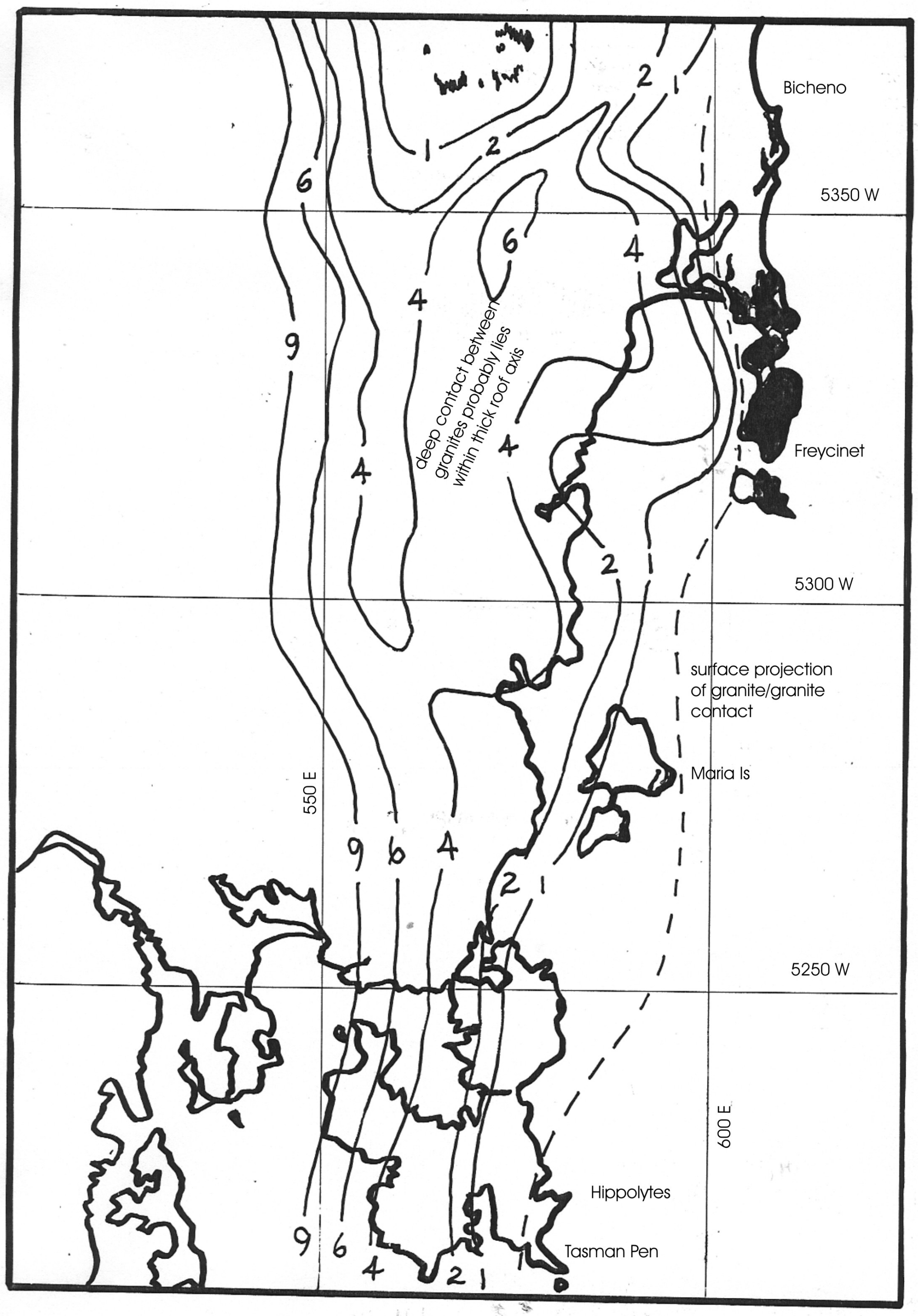

Figure 5: Revised granite surface model