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A geophysical model of the major Tasmanian granitoids

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Abstract

Interpretation of the residual gravity map of Tasmania (mainland Tasmania only) has allowed the compilation of a map showing the shapes of the larger Devonian–Carboniferous granites and, where data density and rock mass permit, the associated granodiorites. The model is based on the current (June 2003) database and will be revised as further data are acquired.

Introduction

The first attempt to define the gross form of the Tasmanian granitoids was by Leaman *et al*. (1980) and entailed filtering the gravity data set to allow removal of some regional effects, and then modelling of the granites and the Moho surface. At that time the available gravity maps were derived from a data set where most of the gravity stations were 5 to 7 km apart (fig. 1).

Data acquisition by the Tasmania Department of Mines (now Mineral Resources Tasmania) (East Coast Coal Project, Zeehan granite study, Midlands groundwater study, and the Mt Read Volcanics Project), the University of Tasmania, and exploration companies has improved the station spacing to better than two kilometres over about 25% of Tasmania. Leaman (1986*a*) showed that it may be possible to use a crustal model to extract crustal components of the gravity field and so enhance the value of the data for specific projects.

These advances resulted in the first edition of a comprehensive geophysical model for the granitoids (Leaman and Richardson, 1992). This report presents an updated assessment of that model.

Data and Methods

Only public-domain gravity and magnetic data have been used for this study. All data are available from Mineral Resources Tasmania. The gravity data are held in the databases TASGRAV (whole-State regional) and MTREAD (data acquired for the Mt Read Volcanics Project in west and northwest Tasmania, supplemented by company data). All stations have been reviewed and checked for errors and consistency (refer to Richardson and Leaman, 1987) and fully corrected (including 20 km terrain corrections). The coverage remains somewhat uneven on a State or regional basis (see inset, fig. 4).

Several regional aeromagnetic surveys, with a nominal line spacing of 500 m and terrain clearance of 150 m, cover western, northwestern, central north and part of northeast Tasmania (Corbett *et al*., 1982; Leaman, 1986*b*; Bishop, 1986, 1987; Richardson, 1989) and were completed before the first edition of this report. More detailed surveys have been completed in the last decade. The most recent surveys and integration have covered northeast Tasmania (NETGOLD) and western Tasmania (Western Tasmanian Regional Minerals Program) with line spacings of the order of 200 m and terrain clearance of less than 100 metres. The remainder of Tasmania is covered with a 1500 m line spacing (BMR, 1988).

The provisional results of analysis of these databases, as presented here, are based on an extended, but still fundamental, evaluation. This evaluation has not been directed solely at extraction of information relevant to the granites but rather at the simultaneous solution of the contributions from basement blocks and forms, troughs, crustal structure and first-order structures in the upper crust. The key elements of the interpretation depend on the gravity databases, and the various factors listed above have been assessed by a series of long, randomly-orientated but overlapping profiles modelled in accordance with the procedures outlined in Appendix 1 of Leaman and Richardson (1989) and the very stringent criteria of Leaman (1994). The effect of application of these criteria has not yet become fully apparent due to a decrease in exploration and interpretation activity but some indication was provided by Leaman (2002) for western Tasmania. Further significant changes in interpretations are to be anticipated when these rigorous controls are applied to portions of the data set not recently reviewed in detail.

The results presented in the first edition of the model were largely based on two-dimensional methods, and it was known that three-dimensional methods will always lead to revisions wherever applied, and where data permit. Many variations indicated here reflect the application of 3D methods to several plutons (especially Heemskirk–Pine Hill–Granite Tor and Dolcoath east, model detail in Figure 3). The development of such models, for exploration projects for Renison Ltd and Pasminco Exploration in particular, and the ultimate refinements reported by Leaman (1996*a*, 1999, 2002) has necessitated use of reference and data levels which optimise resolution for particular projects. Consequently, there has been a need to integrate and simplify some elements of these models here and the reader should inspect the original presentations if more detail is required.

A secondary use of granite studies relates to the provision of regional components of the gravity field so that more reliable residual analysis of smaller and shallower sources is possible. Tables of values of regional components for the 'MANTLE88' water (bathymetry) and Moho (derived from the modelled sections) models are presented in Leaman (1988*a*) and further modelling has resulted in more refined values based on the 'MANTLE91' model (Leaman, pers. comm.). The 'MANTLE91' concept was modestly revised by Roach (1994) in northeastern Tasmania. Roach *et al*. (1994) discussed the validity of this approach to regional separations and its general reliability. Figure 2 presents an image of the residual gravity field calculated using the current version of the Mantle model. Most of the granitoids are evident in anomaly relief but a few are disguised because of their limited volume or form, or complex intrusive patterns.

Discussion

Compilation of this model (fig. 4) of the major Tasmanian granitoids was prompted by the continuing use of the model presented by Leaman *et al*. (1980) and Leaman and Richardson (1992). While the 1992 model may be considered generally reasonable, industry and academic use of the 1980 model must lead to difficulties. The 1980 model was presented at a scale of 1:4 000 000 and, as mentioned earlier, was based on filtering the gravity data set to produce a residual. Leaman (1988*b*) presented a revised compilation of the granitoid model for west and northwest Tasmania in 1988. The 1992 model was compiled at a scale of 1: 500 000 but was suitable for presentation at scales as large as 1: 250 000 in many areas.

The present model has been compiled at similar scales and is intended for general use at scales smaller than 1:250 000. Some portions of the model are available at scales which permit presentation at scales larger than 1:100 000. The model is not regarded as final and may be refined in all areas. In many cases further detail cannot be supported by the extant data. The model has highest reliability in central western Tasmania.

The model is presented for Devonian–Carboniferous granitoids, or granitoids generally considered to be of this age. As noted below, some bodies may not fall into this family. Granodiorites are only shown where there are substantial volumes or sufficient data to provide satisfactory definition.

Cambrian granites have not been included in this model. Early work (Leaman and Richardson, 1989) suggested that most were small bodies with the intrusion style of pipe-plugs, or occurred as sheets. New work has altered this perspective and some large bodies are involved (see Leaman, 2002 for West Coast Range). Recent dating of rocks at South West Cape indicates that part of the large granite mass inferred beneath southwest Tasmania is Cambrian in age. It is unclear how much of this large intrusion is Devonian and how much Cambrian at this stage and further data are required. The southwest Tasmanian pluton is included in this model but it is suspected that the western half of the feature might be Cambrian in age, given the new work along the West Coast Range.

Major features of interest are the steep nature of the western boundary of the East Coast granites and adamellites, the large size of the southwest granitoids, and the approximately east-west cutoff at the southern boundary of the West Coast granites. The extent of the granodiorites is poorly defined except in the east Tamar area.

This compilation includes new analyses of the Beulah and King Island granitoids (Leaman, 2003). The **Beulah Granite** was ill-defined by older analyses because of poor outcrop and indications only in regional profiles. A large, low density mass was involved but it was a shadowy body set in a Cambrian volcano-sedimentary setting which was itself little known and poorly defined. It still is. The new residual separation techniques do allow some assessment and there have been considerable changes in interpretation. Further, the supposed outcrops of the granite, actually described as granodioritic by Leaman and Richardson (1989) based on old mapping, are now thought to be Cambrian andesitic rocks. This intrusion remains somewhat uncertain in complete form but further review will not be possible until the data coverage is significantly improved and more is known of the stratigraphy and properties of the Cambrian sequence in the region.

Similar comments apply to the **King Island granites** which have intruded a Precambrian granitoid suite. Some problems of resolution and detail relate to a conflict of similar properties, intrusion history, and to some limitations in the data set, but the onshore interpretation at shallow depths is considered a reliable indication. The form offshore is not well controlled and the plutons may be more extensive to the north and northeast of the island.

There have been modest adjustments to the form of the **Meredith Granite**, as required by ongoing refinements in other intrusions, implications of a seismic traverse across the southern face, and the work of Webster (2002). This body remains the least studied of the granites in northwest Tasmania and no significant changes will be possible until the data coverage around and across the body is upgraded.

The form of the **Dolcoath Granite** has been refined by ongoing analysis allied to the seismic reflection profile along its southern face (Leaman, 2002). The general form of this intrusion along its southern face and east of 405 000 mE is considered to be well defined.

Within the group of granites in northwest Tasmania only the **Housetop Granite** is anomalous and it has been the subject of considerable review. This granite mass, or masses, is problematic and ironically has one of the best data coverages of all intrusions. Both the coverage and the intrusion are exceptional.

Leaman and Richardson (1992) based the model of this granite on the analysis of Leaman and Richardson (1989) which suggested a normal plutonic form whilst noting that many of the inferred and observed properties were not consistent. The 1989 study and 1992 model were based on regional long-line analyses supported by some detailed work on the shallow form near the Dial Range and Kara mine. Each of these studies indicated that at least part of the granite extended to considerable depth but magnetic data, not supported by observed properties, indicated otherwise. Magnetic anomalies were assigned to elements of the granite. Acquisition of further magnetic data, and regional and local analysis of structures extending from Bass Strait to Macquarie Harbour, challenged this view. Comparable anomalies were clearly related to deeply buried slices of Cambrian ultramafic rocks within a thrust terrane (Leaman, 1992, 1994; Leaman *et al.*, 1994 for summaries; Roach, 1994; Leaman, 1996*b*). It was thought possible that this intrusion might be overthrust or intruded above a piece of ultramafic rocks.

These implications were taken up by LeClerc (1996) who suggested that the Housetop Granite was sliced by thrusts and was essentially a lopolithic shape. This was a return to the interpretation of Sheehan (1969), who had implied a pipe and sheet form with the pipe/dyke to the east side. LeClerc considered only a wedge sheet within a thrust context. This overlooked the regional aspects which had so concerned Leaman and Richardson (1989) and which were verified by Leaman (2002). A sizeable portion of this intrusion does extend to depths in excess of 5 to 6 kilometres but a comprehensive 3D analysis is required for this body and associated rocks.

The present compilation is generally faithful to the consistent elements of Sheehan and LeClerc (to the west) and to LeClerc and Leaman (to the east). The principal problem is how, or whether, this body is connected to other plutons (Meredith and Dolcoath especially) and what type of structures have influenced the present form. The residual Bouguer anomaly map shows a major trend or discontinuity arcing around the Great Western Tiers towards northwest Tasmania and this intersects the major thrust zone SSW of Burnie–Ulverstone which extends into central western Tasmania — on the southern side of the Housetop Granite. The age of the granitoids relative to this structuring is, therefore, an issue. Leaman (2002) presents a diagram which relates this granite to the possible termination and control of some structuring which would suggest that it pre-dates at least one generation of thrusting.

The interpretation of the **Pieman Granite** has also been modified to accord with Webster (2002) and some on-going refinement but further definition of this intrusion, especially northward, depends on the acquisition of infill data.

The large intrusion in southwest Tasmania has been refined slightly but widely-spaced gravity stations do not permit further analysis. As noted in the introductory comments above, a part of this body is now known to be Cambrian in age.

The distribution and form of granodiorites west of the principal **East Tasmanian Batholith** complex has been reviewed using Roach (1994), Leaman (1996*b*) and Leaman (2002) and some on-going analysis. This work indicates that some of these intrusions have been overthrust and sliced and may not extend as far west as previously thought, especially in northern Tasmania. An additional body, inferred to possess granite-adamellite properties, has been indicated near the mid-Tamar region and this is included in the new compilation, although its extent is not well known. It is not known if other, similar, small plutons occur in the region. Variations associated with granodiorite roof form are restricted to the Lefroy–Lisle region.

Other, more modest variations in the form of the northeast batholith are shown in the Gladstone and Mathinna areas (Roach, 1994). More detailed review is available for the southern extension of the batholith and changes in the model have been based on the compilation of Leaman (1996*b*) and the peninsula interpretation of Leaman (1997).

No analysis has yet been undertaken of the granites of Flinders Island and the surrounding smaller islands of the Furneaux Group.

Conclusion

The geophysical model is a work in progress and must be treated as a current status provisional guide. Unless original sources are inspected for detailed elements no enlargement of scale is warranted.

References

BISHOP, J. R. 1986. Interpretation of the North-West Tasmania aeromagnetic survey. *Geophysics Report Mt Read Volcanics Project Tasmania* 4.

BISHOP, J. R. 1987. Interpretation of the North Tasmania aeromagnetic survey. *Geophysics Report Mt Read Volcanics Project Tasmania* 6.

BMR, 1988. *Total magnetic intensity contours Tasmania. 1:500 000 scale map*. Bureau of Mineral Resources, Geology and Geophysics Australia: Canberra.

CORBETT, K. D.; RICHARDSON, R. G.; COLLINS, P. L. F.; GREEN, G. R.; BROWN, A. V. 1982. The 1981 West Coast aeromagnetic survey: summary of information and results. *Unpublished Report Department of Mines Tasmania* 1982/39.

LEAMAN, D. E. 1986*a*. Gravity interpretation west and north west Tasmania. *Geophysics Report Mt Read Volcanics Project Tasmania* 3.

LEAMAN, D. E. 1986*b*. Preliminary interpretation report: 1985 West Tasmania aeromagnetic survey (Macquarie Harbour south to Elliott Bay) *Geophysics Report Mt Read Volcanics Project Tasmania* 2.

LEAMAN, D. E. 1988*a*. MANTLE88. Regional gravity field, Tasmania. *Geophysics Report Mt Read Volcanics Project Tasmania* 8.

LEAMAN, D. E. 1988*b*. Regional evaluation — west and north west Tasmania. Precambrian and Lower Palaeozoic structural relationships. *Geophysics Report Mt Read Volcanics Project Tasmania* 7.

LEAMAN, D. E. 1992. Finding Cambrian keys: An essay in controversy, prospectivity and tectonic implications. *Bulletin Geological Survey Tasmania* 70:124–148.

LEAMAN, D. E. 1994. Criteria for evaluation of potential field interpretations. *First Break* 12:181–191.

LEAMAN, D. E. 1996*a*. *Heemskirk, Pine Hill, Granite Tor: notes to accompany April 96 granite model*. Report for Pasminco Exploration by Leaman Geophysics [Unpublished].

LEAMAN, D. E. 1996*b*. *Map of geology and structures as base of Parmeener Super Group in Central Tasmania*. Report for Regional Forest Agreement and Mineral Resources Tasmania [Unpublished].

LEAMAN, D. E. 1997. Gravity survey and structure of the Forestier Peninsula, southern Tasmania. *Papers and Proceedings Royal Society of Tasmania* 131:77–84.

LEAMAN, D. E. 1999. *Three dimensional model of Heemskirk, Pine Hill and Granite Tor granites*. Unpublished data supplied to Mineral Resources Tasmania [First release in Leaman, 2002].

LEAMAN, D. E. 2002. Quantitative interpretation of magnetic and gravity data for the Western Tasmania Regional Minerals Program. Part 1. *Record Tasmanian Geological Survey* 2002/15.

LEAMAN, D. E. 2003. The form of the King Island and Beulah Granites. Report for Western Tasmania Regional Minerals Program. *Record Tasmanian Geological Survey* 2003/06.

LEAMAN, D. E.; RICHARDSON, R. G.; SHIRLEY, J. E. 1980. Tasmania — the gravity field and its interpretation. *Unpublished Report Department of Mines Tasmania* 1980/36.

LEAMAN, D. E.; RICHARDSON, R. G. 1989. The granites of west and north-west Tasmania — a geophysical interpretation. *Bulletin Geological Survey Tasmania* 66.

LEAMAN, D. E.; RICHARDSON, R. G. 1992. A geophysical model of the major Tasmanian granitoids. *Unpublished Report Department of Mines Tasmania* 1992/11.

LEAMAN, D. E.; BAILLIE, P. W.; POWELL, C. McA. 1994. Precambrian Tasmania: a thin-skinned devil. *Exploration Geophysics* 25:19–23.

LECLERC, M. 1996. *The geophysics of the Housetop Granite*. B.Sc (Hons) Thesis. University of Tasmania.

RICHARDSON, R. G. 1989. The Mangana–Alberton aeromagnetic survey — a preliminary interpretation. *Report Department of Mines Tasmania* 1989/19.

RICHARDSON, R. G.; LEAMAN, D. E. 1987. TASGRAV — the Tasmanian Gravity Data Base. *Unpublished Report Department of Mines Tasmania* 1987/02.

ROACH, M. J. 1994. *The regional geophysical setting of gold mineralisation in Northeast Tasmania*. Ph.D. Thesis. University of Tasmania.

ROACH, M. J.; LEAMAN, D. E.; RICHARDSON, R. G. 1994. Comparison of regional–residual separation techniques for gravity surveys. *Exploration Geophysics*, 24:779–784.

SHEEHAN, G. M. 1969. *Gravity field in the Sheffield area*. B.Sc. (Hons) Thesis. University of Tasmania.

WEBSTER, S. S. 2002. Quantitative interpretation of magnetic and gravity data for the Western Tasmanian Regional Minerals Program. Part 2. *Record Tasmanian Geological Survey* 2002/15.

[30 September 2003]

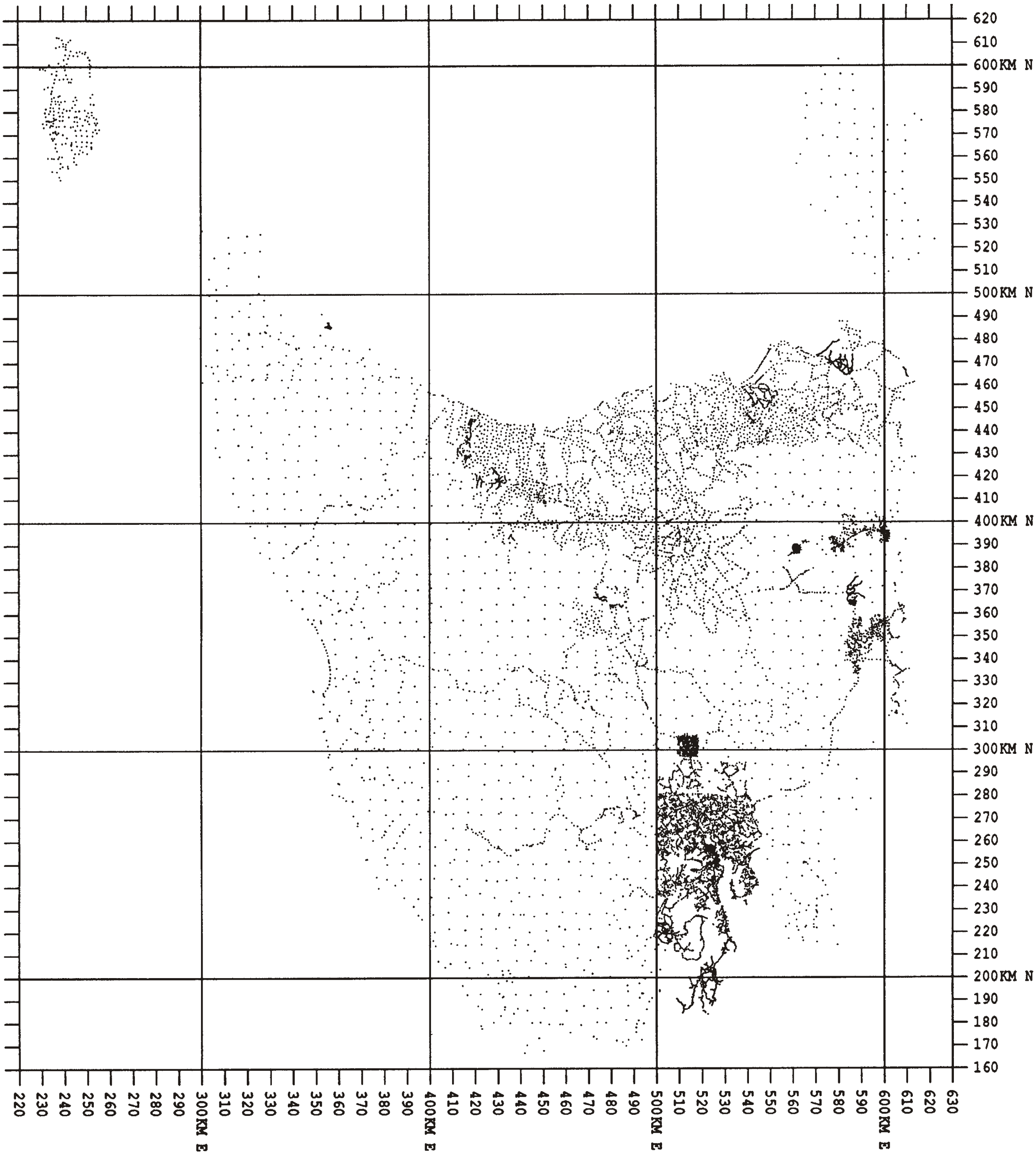

Figure 1

Gravity station distribution as in 1980

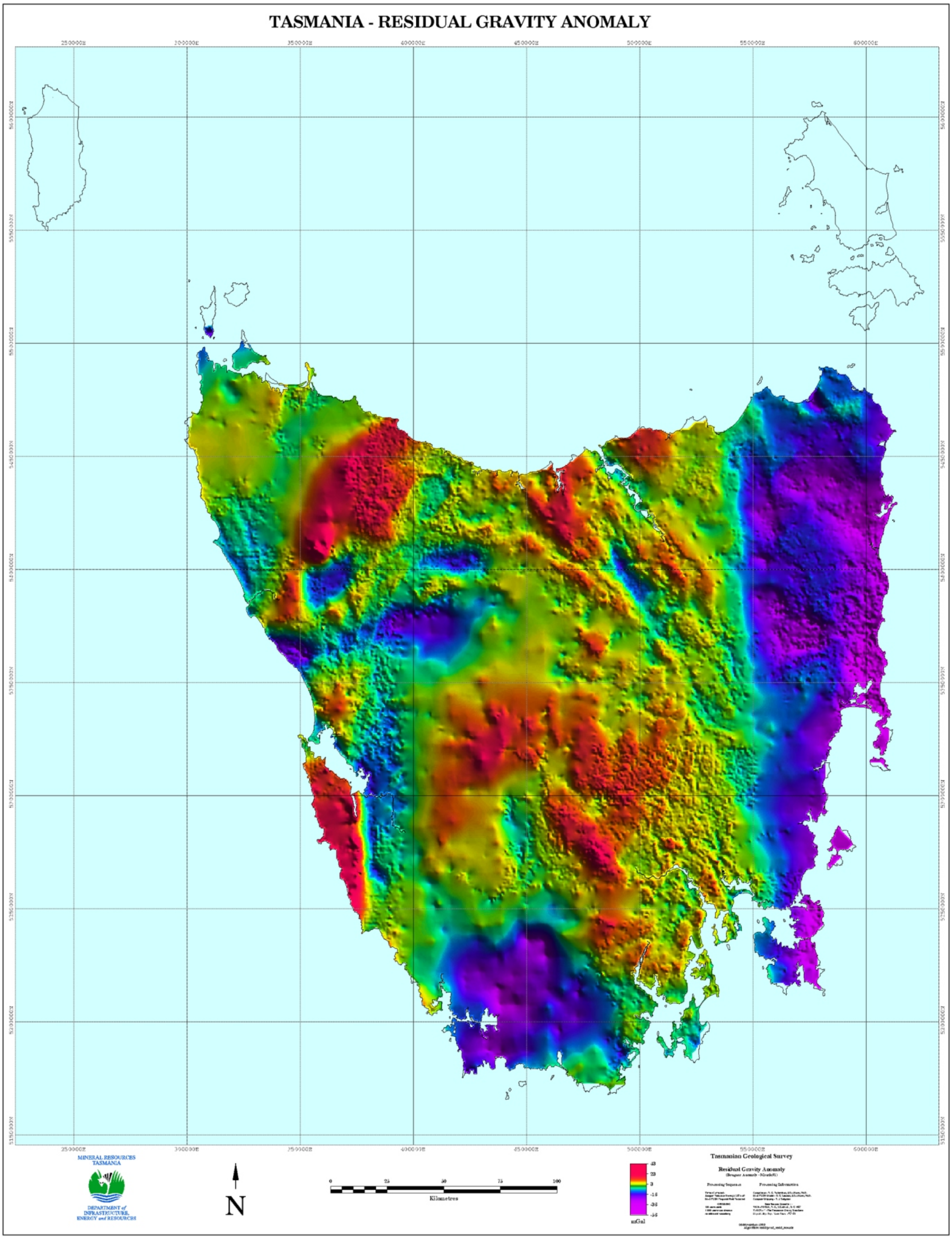

Figure 2

Image of residual Bouguer anomaly as in 2003

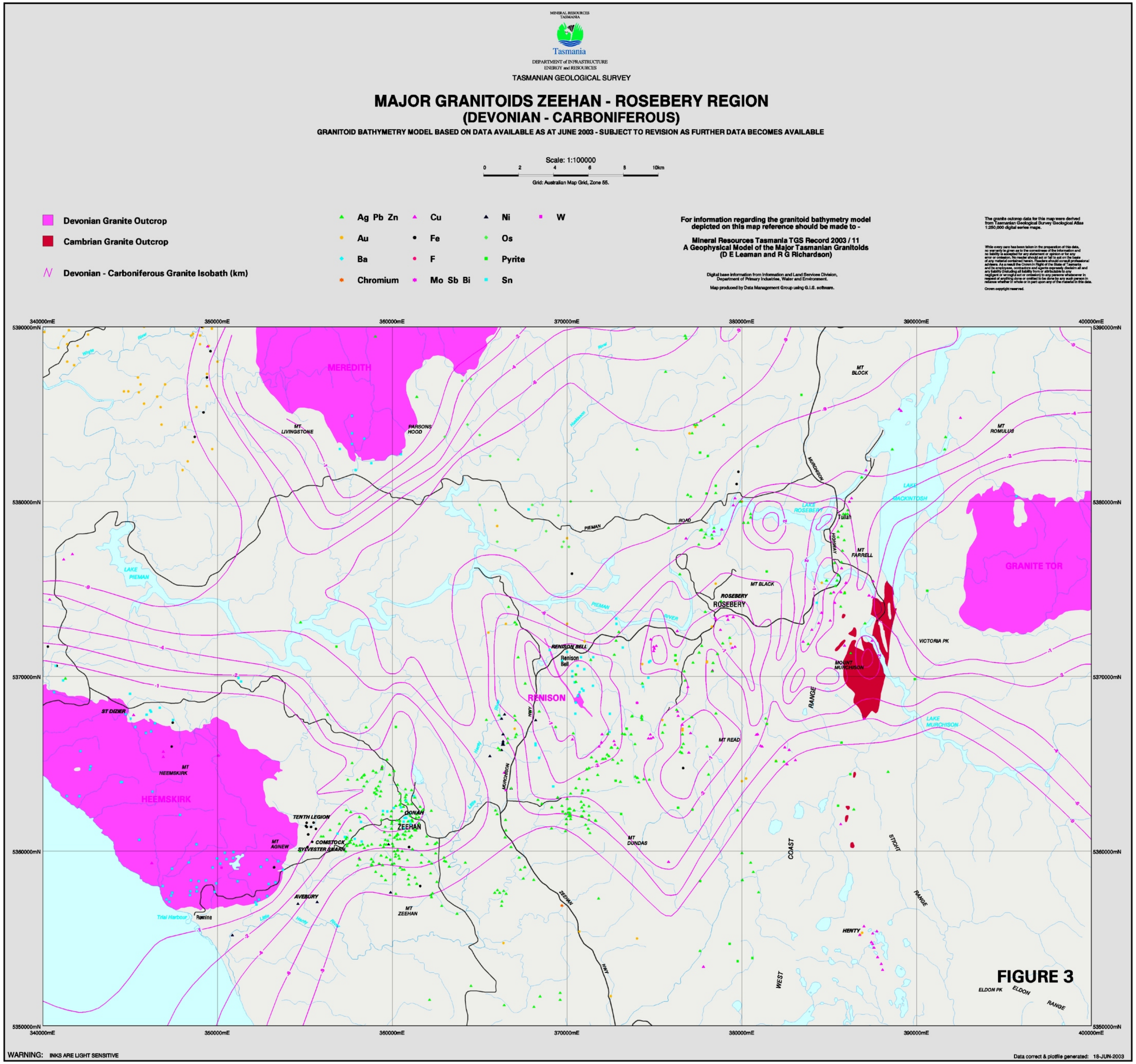

Figure 3

Portion of 3D model showing the Zeehan–Renison–Sterling Valley region (Note: this is a reduced-size image of this map, full-size maps are available from Mineral Resources Tasmania)

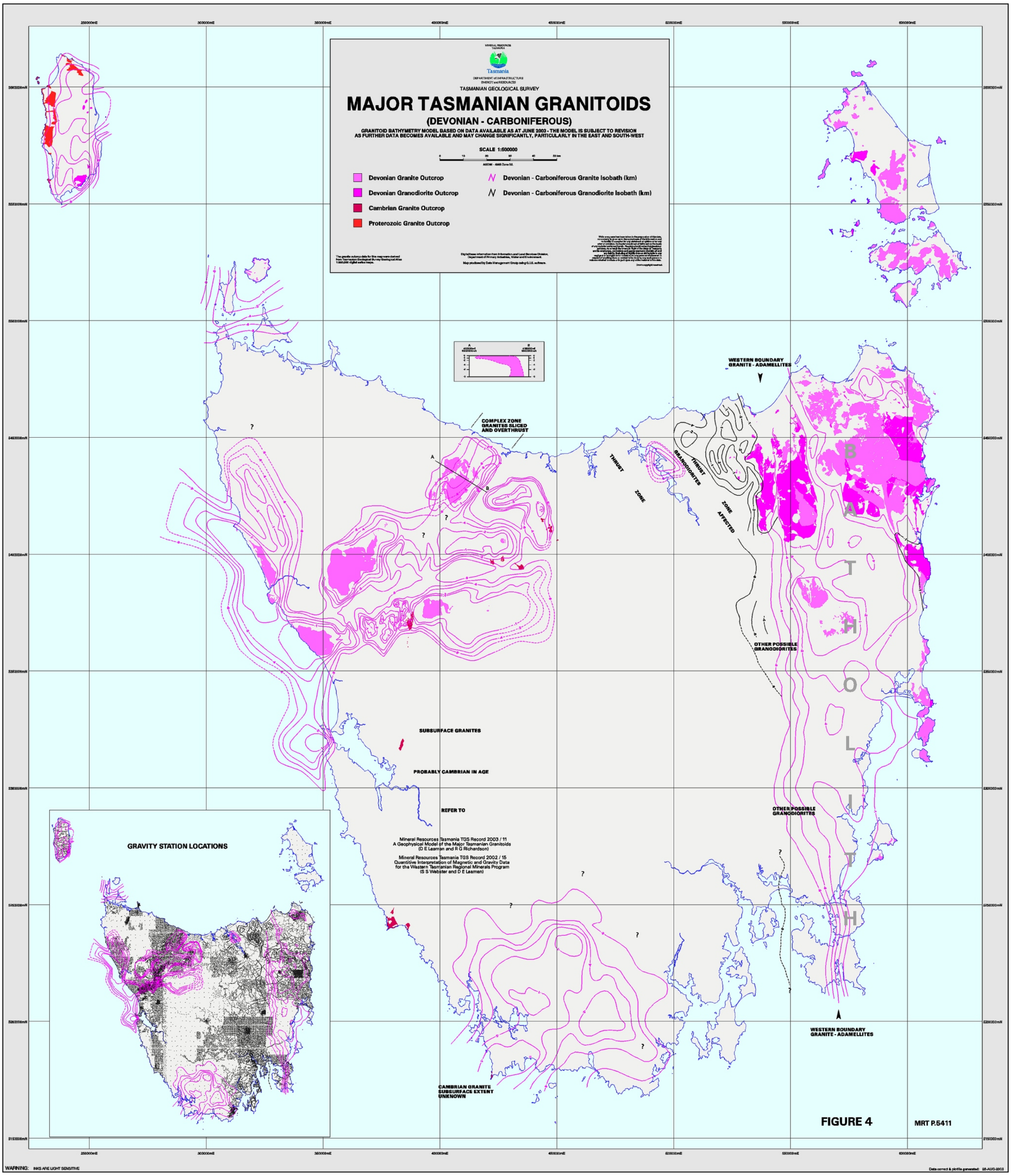

Figure 4

Granitoid bathymetry and current gravity station distribution
(Note: this is a reduced-size image of this map, full-size maps are available from Mineral Resources Tasmania)