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Western Tasmanian Regional Minerals Program

The form of the King Island and Beulah granites

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Introduction

An element of the Western Tasmanian Regional Minerals Program involves definition of granite aureoles in western and northwestern Tasmania and their possible relationships with mineralisation, prospectivity and further exploration.

Some previous attempts have been made to define granitoid forms in Tasmania, the first being Leaman *et al.* (1980), with more comprehensive treatments by Leaman and Richardson (1989) (partly revised as Leaman and Richardson, 1992), and a detailed analysis of a section of central western Tasmania (Leaman and Webster, 2002). These outlines have been based on gravity data available at the time, with some constraints applied using magnetic data, especially where alteration-related anomalies assist definition of the granitoid roof. The granitoids of King Island were included in the 1980 analysis but have not been subsequently examined. The Beulah Granite, based on presumed exposures in the Beulah–Paradise area as shown on regional maps since about 1960, was assessed *en passant* as part of the regional studies undertaken for the Mt Read Volcanics Project; the results were reported by Leaman and Richardson (1989). Neither the Beulah Granite, nor the bodies on King Island, have ever been examined individually or in detail.

There have been various reasons for this situation.

The Beulah Granite has not been obviously associated with rich or large deposits, or even many mineral deposits. There has been, consequently, little exploration pressure and the geophysical database is of regional standard only.

King Island, however, was far removed from the regional studies in northwest Tasmania and the network of gravity and magnetic profiles examined for the other projects. Further, and most crucially, there was either little confidence in the database on the island or the data coverage was extremely patchy. Public domain gravity data available in 1986–1989, for example, were widely spaced and indicated little variation in values which might correspond to granitoid relief. There was no pattern which might be associated with major, and especially siliceous, granitoids as on nearby Three Hummock Island. This was an unexpected situation given the extant regional mapping (Department of Mines 1:250 000 scale) or general outlines such as Turner (1990).

The present review seeks to redress both situations and to define the forms of any plutons present within the limits set by available data and the time allocated for analysis. The data provide the greatest constraint on the interpretation offered.

King Island

Several granitoids have been mapped on King Island. The oldest suite (approximately 730 Ma) is exposed along the west coast and near Cape Wickham at the northern tip of the island. This late Proterozoic suite includes a porphyritic biotite adamellite (dominant lithology) and minor biotite granodiorite, an even-grained biotite adamellite, a biotite-muscovite granite, and sundry aplites and pegmatites. No information on the physical properties of these rocks is available.

The Devonian–Carboniferous granitoids are exposed in the eastern parts of the island, near Grassy (granodiorite), Bold Head (adamellite), and Mount Counsel (granite). Little is known about these intrusive rocks (e.g. Camacho, 1989) as emphasis has been placed on associated alteration and mineralisation in the Grassy–Bold Head area.

Regional gravity data have been available since 1967 (University of Tasmania projects) but, as explained by Leaman (1992), there were base and correction uncertainties. All older data were acquired in an era when base maps and elevation controls were very limited. Geopeko Limited augmented this database in 1982 but, again, there were problems in unification and reference. Surveys were individual entities with different control elements. Leaman (1992) was engaged to assess this situation, correct it if possible, and make recommendations. Geopeko subsequently completed an additional survey and the entire database was reduced from original observation sheets and integrated to within reasonable tolerances — estimated at the time to be of the order of 1 mgal in reduced Bouguer anomaly. It was then interpreted regionally in the particular context of an exploration licence in the central south of the island (Leaman, 1993). The database was further upgraded in 1995 by a university project team.

There is now a fair regional coverage of the entire island at standards which are acceptable. Survey cross checks and repeated station occupation lends some confidence to the entire data set although there are clearly some stations which might be suspect. Unfortunately most of the coverage is in the southeast quadrant of the island and there are large gaps in other regions. These gaps inevitably mean that interpretation and resolution is limited in those zones.

The partial island interpretation of Leaman (1993) indicated that there was considerable relief on the granite surfaces, with interpretation problems compounded by the distribution of, and consequent density contrasts associated with, the two Precambrian rock suites on King Island; more or less metamorphosed. The 1993 study presumed some gross physical properties for the granitoids (Precambrian and Devonian– Carboniferous) on the basis that the older rocks were dominated by granodiorite (approximately 2.71 t/m^3) and the younger were slightly mafic granites (2.65 t/m^3). No internal discrimination was attempted. The two Precambrian series were assigned nominal densities of about 2.69 t/m^3 and 2.77 t/m^3. These values appeared necessary to generate some of the local and near-surface contrasts.

The present study has benefited from the 1995 improvement in the database and its reliability, and some reconsideration of the likely bulk densities given further information about the actual rock types present. It must be stressed that no statistically significant sampling of rock types and properties is yet available and this interpretation therefore depends on the interplay of several, quite critical, assumptions.

These assumptions were finalised after preliminary modelling of the entire array of profiles used.

1. The dominant Precambrian granitoid is adamellitic and has a density of the order of 2.65 t/m^3 or less.
2. Other local variations in the Precambrian granitoid complex may range from 2.69–2.71 t/m^3.
3. The largest Devonian–Carboniferous granitoids have a bulk density of about 2.62–2.64 t/m^3 and are typically represented by the Sea Elephant Pluton (Mt Counsel) and Bold Head Pluton.
4. The Grassy Granodiorite must possess a density consistent with such a description (2.70–2.71 t/m^3), but the responses imply a relatively insignificant volume of material. This option was tested and found to be the case. The granodiorite has been intruded by another adamellite/granite.

It is clear that any modelling of the gravity field, or magnetic field, on King Island is dependent on such assumptions and the consistent implications of an array of interpreted sections. The interpretation is consistent with the parameters defined by Leaman (1993) for a valid potential field interpretation. These parameters do not ensure correctness, simply a valid and internally consistent assessment. Modelling using two-dimensional methods has been undertaken on an interlocked set of E–W, N–S and variably orientated profiles which reflect the availability of coverage. All lines north of about 5 268 000 mN contain gaps and ill-defined segments. The array methods used minimise the possible deficiencies in the assessment but cannot eradicate them. Doubts about densities of all parts of the geology affect estimates of interface depths but not the gross shapes of structures. Consequently the interpretation provided is the best possible with the current data and control information. The shape of the plutons is considered valid but the depth to roof of the main plutons is rated as the minimum likely. Tests using a range of realistic bulk density contrasts suggested that the inferred maximum depths to granitoid may be doubled. These values are not considered likely.

The interpretation of depth to granitoid is shown in Figure 1. This interpretation is considered the best possible using the present data set, and 2D methods, and could be used as feedstock for a 3D modelling assessment provided more information about density contrasts was provided. Further evaluation is not justified until the database is further improved and reliable rock property information is available.

Preliminary modelling of the data indicated a regional trend from south to north. The nature of the crustal component was estimated by sampling profiles which traversed at least two exposed plutons. The Sea Elephant Pluton was used as reference anchor and confirmed by responses at Cape Wickham. All models have then allowed for these trends and been adjusted for them. This factor has never been incorporated in any previous modelling on King Island. This approach must yield an improved interpretation, but not necessarily a totally valid one in terms of granite depth due to problems with ill-defined contrasts.

The new interpretation generally confirms the implication of the 1980 study in that the bulk of the island is underlain by granitoids at depths of around 600 to 1600 metres. The Devonian–Carboniferous plutons have intruded the Precambrian bodies and the latter are decidedly granodioritic in the central west

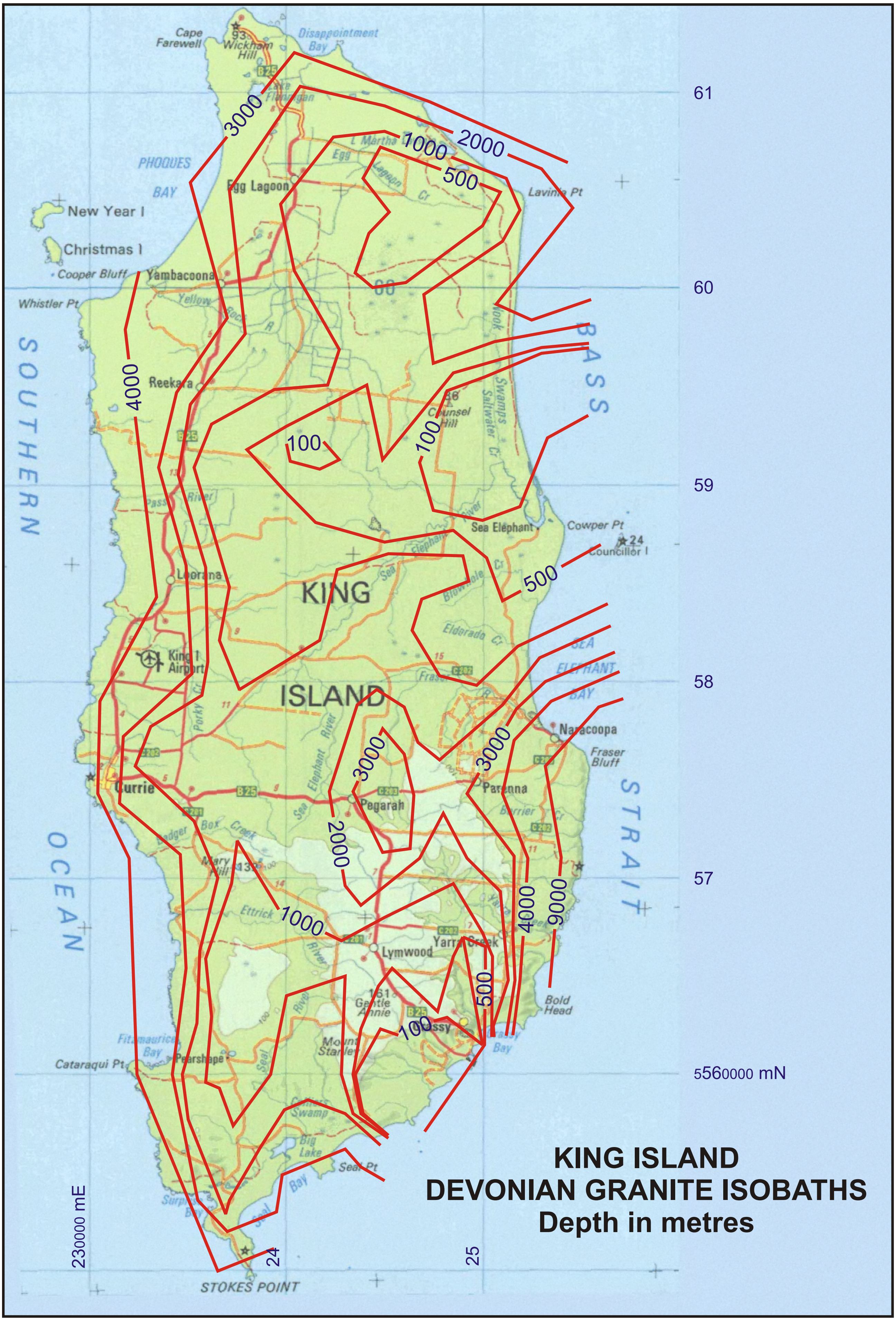
KING ISLAND
DEVONIAN GRANITE ISOBATHS
Depth in metres
61
60
59
58
57
5560000 mN
230000 mE
24
25
3000
2000
1000
500
100
4000
9000
SOUTHERN OCEAN
BASS STRAIT
KING ISLAND
Cape Farewell
Wickham Hill
Disappointment Bay
PHOQUES BAY
New Year I
Christmas I
Cooper Bluff
Yambacoona
Whistler Pt
Egg Lagoon
Lavinia Pt
Reekara
Counsel Hill
Sea Elephant
Cowper Pt
Councillor I
Loorana
King I Airport
SEA ELEPHANT BAY
Naracoopa
Fraser Bluff
Currie
Pegarah
Parenna
Lymwood
Yarra Creek
Gentle Annie
Grassy
Grassy Bay
Bold Head
Mount Stanley
Pearshape
Cataraqui Pt
Fitzmaurice Bay
Big Lake
Seal Pt
Surprise Bay
STOKES POINT

Figure 1

but adamellitic in the north. The form of the structural contours indicates several discrete plutons of which the largest is the Sea Elephant Pluton. The Grassy and Bold Head plutons are much smaller and the greater part of the volume, at depth, of the Grassy Pluton is a very siliceous granite (density approximately 2.60–2.62 t/m^3). The volume of granodiorite is minimal. This light pluton extends to shallow depth a little west of Mt Stanley and a little north of Yarra Creek at Lymwood. An additional small pluton is present north of Pearshape. The eastern limit of these plutons is quite well defined east of Grassy and Yarra Creek and the margin dips very steeply to great depth inland of Bold Head and Naracoopa.

The western margin of the Devonian complex is ill-defined, partly due to the effect of the older granitoid complex and the difficulty of discriminating the various plutons, and the lack of data in the west of the island. The margin of either, or both, pluton complexes is probably well offshore although it may be very close to the coast near Currie. Figure 1 indicates the western margin of the Devonian granites based on their correlation from the eastern exposures and consistent properties, as well as definite contrasts within the areas of exposed Precambrian granites. The present interpretation is constrained by those areas in which data coverage and responses, and granitoid composition, allow identification of contrast or contacts. Not all profiles examined provided clear indications of limits because of variation in contrasts and chemistry within the Precambrian complex itself. It may well be that some of the granite exposures assigned a Precambrian age are in fact Devonian but detailed field work would be required to confirm or deny this possibility. The intrusive interfingering of these bodies cannot be resolved with extant surface or geophysical data and the western limit of the Devonian granites, as shown in Figure 1, should be accepted only as an indication of form. The interpretation of roof depth is much more reliable although, of course, either granitoid family may have been described in the west of the island.

It is clear that the east–west step in the gravity field across the island north of Naracoopa reflects a general change in granitoid relief and depth, from relatively shallow related to the Sea Elephant Pluton, to moderately deep related to the other plutons.

It is recommended that some minor mapping be undertaken to define the internal Precambrian boundaries and the various compositions of the exposed plutons. Rock property determinations are required for all rock types. Additional gravity coverage is required in many areas and all data should then be re-checked for consistency. The subtlety of many deviations in the gravity field, and the inference of a broad, generally shallow pluton complex, means that the quality and coverage of the database must be improved if the interpretation is to be further detailed or extended.

Magnetic data have not been examined in detail because of time constraints but preliminary reviews, especially in the Grassy region, do indicate that this database can be used to trace elements of the granitoid boundaries, constrain roof depth estimates, and map mafic or altered rock units.

Beulah

An interpretation of the form of the Beulah Granite, based on a series of regional profiles, was provided by Leaman and Richardson (1989). It was noted that the name was inappropriate, as the exposed material was then described by other departmental staff as an 'I-type' granodiorite. Little published material or comment is available about the very limited, and presumed, granitic exposures. More recent work suggests that the rocks are possibly andesitic. Leaman and Richardson (1989) noted the difficulty of interpreting this intrusion in the absence of fresh sampling and property determinations, especially as the regional models suggested that the intrusion possessed the density properties of a granite or adamellite and not a granodiorite. Further, every section which sampled the Beulah Granite did so in a manner which required a complex interbalancing of thick Cambrian sections and the pluton. Given that little was known about the pluton or its properties, and the scale of the overlying sections was also uncertainly defined, the interpretation offered was necessarily crude. It was, however, the first attempt to suggest the general distribution and depth of any intrusion in the Beulah–Sheffield region and the inferred properties implied that the body was Devonian in age.

This last assumption might now be challenged as the recent work of Leaman and Webster (2002) revealed that large bodies of Cambrian granite may also exist and each such intrusion should be dated (also J. Everard pers. comm., and property determinations from southwest Tasmania). This report deals only with the form of any pluton in the Sheffield area and cannot resolve any aspect of its age. It may be remarked that the interpretation offered in Leaman and Richardson (1989) is very similar to that of Leaman and Webster (2002) for the hidden Cambrian granite within the West Coast Range, in that the plutons appear to form a general basement for the volcano-sedimentary sequences and may not intrude them. Not enough is yet known to form any conclusion. These comments are relevant to the following discussion as the actual exposures in the Beulah area, probably of andesite, are almost certainly Cambrian in age.

The present analysis sought to utilise any improvements in either geophysical data coverage or mapping and was focussed directly on the region previously interpreted as roof to the granite. Unfortunately this region has only partly benefited from recent mapping programs and the gravity database is much the same as in 1986–1988 when last reviewed. Leaman and Richardson (1989) foreshadowed an improvement in interpretation with

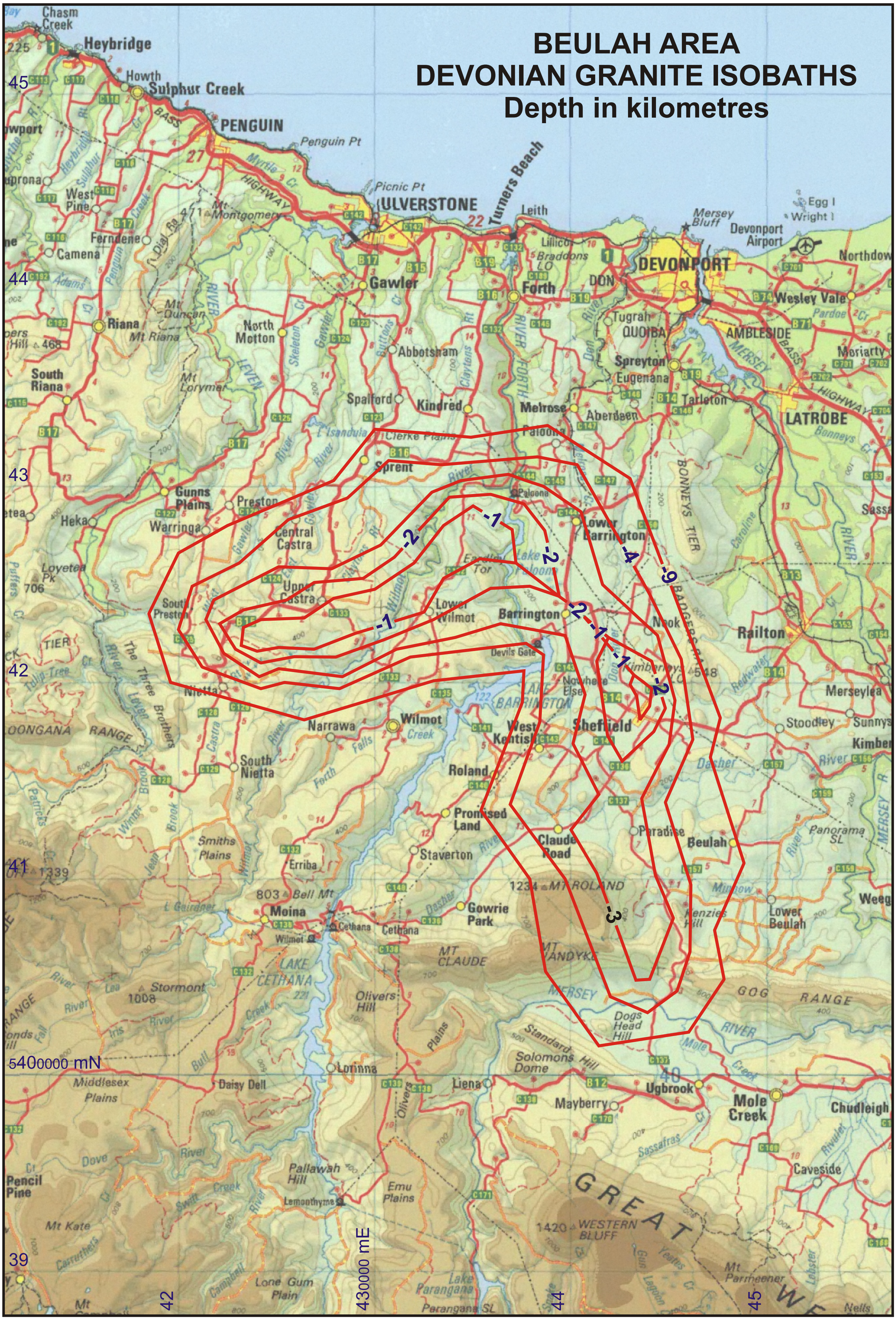
BEULAH AREA
DEVONIAN GRANITE ISOBATHS
Depth in kilometres

Figure 2

the availability of the new residual separation process, then under test, and it is the residual data which have been utilised for the present work. This data format cannot recover problems in quality of individual stations or lack of coverage, but it does reduce many aspects of uncertainty and ambiguity.

The resulting interpretation, now in a format for test in three-dimensional analysis, is provided in Figure 2.

The new and more detailed specific treatment has shown that the pluton is much more restricted than previously thought but the boomerang shape has been confirmed with some caveats. The most reliable part of the interpretation is the limb of intrusion extending ENE from Nietta to Lower Barrington. The geophysical responses are better defined in this area than between Barrington and Mt Roland and this may be due to differences in granitoid composition, depth, or thickness of surrounding Cambrian section. There is little doubt that a large pluton is present; the gravity field cannot be explained in any other way or by any other material, or lack of material. In all sections sampled no correlation could be found between exposed lithologies, or any likely to be at shallow depth, and required or observed responses. The material, previously mapped as granite, is associated with positive Bouguer anomalies with strong gradients indicating that the source is local and of relatively high contrast. This is consistent with the description of the rocks as andesite.

The regional presentation of the observed Bouguer anomalies and the residual Bouguer anomalies appear to provide little indication of a hidden pluton. The residual values provide a hint of the body, its shallowest projection, as a negative response is present and cannot be associated with any surface or near surface unit or sequence. This is a cautionary note: qualitative inspection of data which does not consider the implications of actual contrasts or sequence thicknesses may be misleading. The process of modelling, which demands a quantitative assessment of interacting contrasts, soon exposes what is possible and what is required. This comment is included because the reality of the granitoid is not in question, although the gravity field does not display the same character as associated with exposed granitoids elsewhere in western Tasmania. Similar doubts have been expressed about the body of granite inferred beneath the West Coast Range (Leaman and Webster, 2002) as the gravity responses appear different in character. In each case, Beulah and West Coast Range, the field responses are determined by the relief and size of cupola projections, the general depth of the roof, and the composition and density of the covering rocks.

The arms of the intrusion appear to intrude segments of the Cambrian sequences and extend to quite shallow depths (of the order of one kilometre) in two areas. It is unlikely that the intrusions extend to depths of less than 750 metres anywhere based on the existing data. The implied density of the granite is of the order of 2.62–2.63 t/m^3, as inferred by Leaman and Richardson (1989) regionally.

The interpretation is weakest in the area south of Sheffield where there are very large gaps in the data. Whilst every attempt has been made to select profiles which maximise data availability, some critical areas cannot be reviewed with assurance.

It is recommended that some minor ground reviews be undertaken in the areas north of Barrington and east of Sheffield to check if any evidence exists of distant metamorphism which might be consistent with the presence of a large pluton.

Any further interpretation in this area could be more intensively supported by available magnetic data, also moderately dated, but really requires some infill of the gravity database. A nominal two kilometre spacing in the large gaps present would transform interpretive possibilities. The region further west and northwest has been covered with a nominal one kilometre spacing. Further consideration and mapping of the Cambrian rocks, including details of likely sequence content and thickness, would also assist future modelling. The model provided could be used as feedstock for a three-dimensional analysis but this is not warranted without some improvement in data coverage and sequence knowledge.

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