1979/46. Structural profile across Tasmania. Implications of geophysical surveys.

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Abstract

Preparation of a structural profile across Tasmania for the International Geodynamics Project has raised many queries concerning structures of crustal scale. Available geophysical data have been utilised, with minimal interpretation, to offer preliminary or partial solutions to these queries.

INTRODUCTION

N.J. Turner has been requested to collect information concerning geological structures in Tasmania and to produce a structural profile across the Tasman orogenic belt. The composite profile to be offered to the International Geodynamics Project (Working Group 9: Tectonics) I.C.G. extends from north-west to north-east Tasmania.

Since the terms of reference supplied include acquisition and summation of geophysical data, as well as use of this data to restrict structural options for section preparation, a number of queries have been made and these are answered below in question and answer format. No new data has been collected which would in many cases, resolve problems. Similarly, revisions of extant interpretations have been minor or specific to the queries.

At the time of request, a comprehensive evaluation of the gravity field in Tasmania is under way and unfortunately only the most general aspects have been provided in time for this Project.

Question 1. The Tamar fracture

(a) its geometry - depth and dip
(b) surface width, width at depth
(c) given the Ordovician-Lower Devonian variations in the region, is there a contrast in the character of the crust across the fracture?

Answer 1.

(a) Insufficient evaluation has been done to date to establish dip of the feature, but it persists through the crust. The overall dip-effect is to create a Moho dip to the south-west, but this may be a summation of steeply dipping dislocations.

(b) The gravity field is disturbed from Devonport to George Town. Surface structures are variable across this zone and the plunge of the Moho reflects the effect across the entire 25 km. It appears likely that both surface and mantle width of the zone is at least 20 km.

An implication might be that the axes of Tertiary sedimentation and faulting reflect marginal zones recently adjusted. It could be expected that the material in this zone would be significantly different from those around it for the pre-Cambrian period - presumably the youth of the structure.

(c) No significant variations have been detected in the character of the deep crust across the feature, with the possible exception of the material contained in its 25 km width. Velocity and density information appear consistent on either side.

Question 2. Precambrian rocks

(a) Singleton Thrust, Goat Island. Any geophysical evidence for a west dipping, shallow structural boundary to the Burnie Formation near Ulverstone?
(b) Are metamorphic rocks continuous to Cradle Mountain beneath the Fossey Mountain Trough?
(c) Any evidence to suggest the nature of basement to the Forth and Cradle Mountain metamorphosed blocks and the unmetamorphosed regions?
(d) The dip and depth of the Arthur lineament.

Answer 2.

(a) No sufficiently specific geophysical work has been undertaken to comment.

(b) Probably but not certainly. Insufficient seismic and gravimetric data are to hand to confirm this.

(c) The only data relevant to the nature of the basement as a whole is currently provided by the bulk density and velocity estimates (approximately 2.74 - 2.78 t/m^3; 5.84+ km/s.). These values certainly suggest a crystalline metamorphic basement. A complicating feature under investigation is the presence of major concealed batholith(s) centred on Guildford, but underlying most of the Cradle Mountain region and the Waratah-Que River region.

(d) The regional gravity survey shows an elongate positive anomaly corresponding to the zone of altered rocks comprising the lineament. Regional interpretation of the survey is incomplete, but the asymmetric character of the entire anomaly is consistent with a steep westward dip, although numerous other factors (such as ultramafics, nearby granites *etc.*) do complicate this simple picture. No estimate of the depth of the lineament is possible at present.

Question 3(a). Pre-Middle Devonian Palaeozoic rocks: (West Coast belt)

(i) dip and depth of zones of ultramafic rocks.
(ii) any evidence of ultramafics extending toward either Trial Harbour or Queenstown-Strahan?
(iii) any evidence relating to form of Mt Read Volcanics?
(iv) any evidence on dip, depth and extension of the Henty Fault?
(v) thickness of Cambrian deposits in the belt.
(vi) is the basement metamorphosed or unmetamorphosed?

Answer 3(a).

No available geophysics is sufficiently detailed to offer suggestions on any of the above. A gravity survey with a station spacing of 1 km coupled with some detailed magnetic traverses and seismic reflection soundings could probably answer i, ii, iii, v and possibly iv, vi. By contrast the existing coverage is nearly an order of magnitude too large.

Question 3(b). Pre-Middle Devonian Palaeozoic rocks: (Dial Range Belt)

(i) form of the Lobster Creek Volcanics.
(ii) depth of Cambrian deposits in the belt.

Answer 3(b).

No available relevant information at the appropriate scale.

Question 3(c). Pre-Middle Devonian Palaeozoic rocks: (Fossey Mt Belt)

(i) thickness of Cambrian deposits.
(ii) nature of basement.

Answer 3(c).

No specific information is available concerning the nature of basement but an estimate of 5-6 km has been placed on the thickness of Cambrian rocks following preliminary examination of gravimetric and seismic data.

Question 4. Structures, Deloraine - Scottsdale

Any extension of Precambrian-Cambrian structures south-east from Sassafras-Badger Head-Beaconsfield?

Answer 4.

Gravity anomalies east of the Rubicon River suggest a possible continuation of the Port Sorell Cambrian rocks toward Westbury. Similar anomalies south-east of Beaconsfield toward Exeter may also be interpreted as a continuation of lower Palaeozoic rocks beneath a relatively thin Permian veneer.

Question 5. Devonian granites

(a) contact dips of Heemskirk, Granite Tor bodies.
(b) crustal structure below Scottsdale batholith.
(c) form of granodiorite/adamellite contacts in Scottsdale batholith.
(d) crustal structure below Blue Tier batholith.
(e) form of intrusives in Lottah area.
(f) dip of granodiorite/adamellite contact at Musselroe River and west of Ansons Bay.

Answer 5.

(a) Dip of the Heemskirk and Granite Tor bodies is currently under examination, but the data appears inadequate for any but the broadest comment. Both intrusions are probably parts of a single large batholith with the main portion of the roof at a depth of 1-3 km.

(b, d) Until independent means of examining batholithic structures are established or refined, gravity models cannot provide answers to such questions. Too much ambiguity exists in present interpretations. Seismic data has not yet been examined.

(c) Several of the contacts related to the Scottsdale batholith have been discussed by Leaman (1977). Unfortunately survey detail is insufficient to improve upon earlier analyses. Further, due to broad coverage and Tertiary sediments around Mt Stronach, it is not possible to comment on the possibility of a low angle plunge to the adamellite/granodiorite contact west of Mt Stronach. However, anomaly values do imply that the thickness of granodiorite east of Scottsdale toward Mt Stronach is not great (probably less than 500 m).

(e) The Lottah intrusions were discussed by Leaman and Symonds (1975) and considered to include a significant pipe association. No other interpretation is feasible given the small density contrasts within Blue Tier granitic rocks. For example, if the Lottah intrusives were considered as sub-horizontal sheets within the batholith and possessed a contrast of $-0.02\ t/m^3$, then more than 6 km would be required. Given an overall interpretation implying 8-10 km for the batholith, such a figure is unrealistic, as it virtually implies a large column in any event. The same anomaly ($-60\ \mu m/s^2$) can be more readily explained by considering it to be due to the combined effects of sheets giving a lateral spread and substantial pipes penetrating the batholith.

(f) Control of anomalies in the Musselroe River region is poor but the overall impression is that the adamellite dips shallowly north beneath the granodiorite which may be very thin. Similar problems recur west of Ansons Bay, but the contact between the adamellite of the Ansons Bay Pluton and the granodiorite of the Gardens Pluton appears to be nearly vertical. However, this may be an artificial conclusion, as there is evidence to suggest that the eastern side of the Gardens Pluton contains very little granodiorite and that the Mathinna Beds extend beneath it at shallow depth in a north-west direction from the Bay of Fires. Thus in reality the contact may be between adamellite and Mathinna Beds.

Question 6. Mathinna Beds contact wedges

(a) Does the material at Walduck Hill wedge out at depth or underlie granodiorite?
(b) What is the scale of the wedge between Kapai and Mt Paris? What is the dip of the west side of the Mt Paris mass.
(c) What is the form of the east side of the Mt Paris mass near Rattler Hill?
(d) Extent of material between Poimena and Gardens Plutons.

Answer 6.

(a) The gravity coverage around Walduck Hill is of fair density, and while not good enough to specify contact dips reliably, it seems certain that the adamellite dips at about 40-50° (possibly less) to the west and that the Mathinna Beds form a wedge between this and at least 2-3 km of granodiorite. The maximum thickness of Mathinna Beds in this wedge is estimated at 1.5 km, presuming a near vertical margin to the granodiorite.

(b) No reliable estimate of the dip of the western side of Mt Paris can be given. However, the diffuse nature of the gravity values to hand does suggest a shallow dip to the south-west until west of Ringarooma. The spine of the anomaly related to the Mathinna Beds at Billycock Hill-Legerwood is very narrow at Legerwood and it is possible that the wedge virtually disappears as a major unit south-west of Ringarooma (the Blue Tier and Scottsdale bodies may merge).

(c) Coverage in the region of Rattler Hill is very poor and no refinement of existing interpretations is possible.

(d) The interpretation of this zone, as shown in Leaman and Symonds (1975), indicated a thin slice of Mathinna Beds and a thick slab of granodiorite to the immediate east. Reconsideration of the anomalies associated with the Gardens Pluton granodiorite suggests a better alternative. Overall the granodiorite may be quite thin, less than 2 km thick. To the north, north-east and west it conceals a significant section of Mathinna Beds. The slice exposed is a small part. To the south it conceals adamellite. It is therefore possible that the one kilometre slice exposed is only about 20-25% of the material present. In addition it may be concluded that the Poimena mass dips very steeply eastward.

Question 7. Mathinna Beds

(a) Depth of Mathinna beds in the Lefroy-Bridport and Mt Horror-Lyndhurst tracts.
(b) Dip of pelitic sequences south of Pipers River at Lebrina.

Answer 7.

(a) No estimates of the thickness of the Mathinna Beds are possible with existing data.

(b) Section FG (Leaman, Symonds and Shirley, 1973) summarises the relevant data. Some variation is possible. For example, if the pelitic units form a relatively thin layer, then the anomaly profile shown could still be matched. This would imply that the broad synclinorium indicated encompassed the entire Mathinna Beds section which was lighter than "basement" materials.

Question 8. Granodiorite - Pipers River region

(a) Where is the granodiorite most shallow?
(b) What is the form of the western end of the granodiorite body at Wyena?
(c) How reliable are thickness estimates for the granodiorite?

Answer 8.

(a) East of Wyena a series of cupolas are exposed. West of Wyena cupolas are implied at Lefroy, Retreat and possibly Lower Turners Marsh.

(b) No definitive answer is possible. The general form is that of a shallowly dipping roof abruptly plunging more than 2 km. The actual boundary of the plunging zone is very irregular. The poorly controlled profiles available suggest both eastward and westward dips for the steep part of the contact.

(c) Thickness estimates for the granodiorite are based on the contrast with the Mathinna Beds. This was presumed to be + 0.03 t/m^3 in the original interpretation. If it is presumed that the overall density of Mathinna Beds is 0.10 t/m^3 less (2.57 t/m^3), then the contrast becomes + 0.13 t/m^3 and the granodiorite would be substantially thinner. It is unlikely that these rocks are so universally light. However, presuming that this were the case and that the general spread of small positive and negative anomalies in the Bridport-Nabowla-Lefroy region was due to the combined effects of light Mathinna Beds, granodiorite and denser basement, then the following corollaries would be true. Firstly, the negatives would reflect a thick section or at least a section in which sediment predominated over granodiorite. Secondly, the positives would reflect thickened granodiorite. Thirdly, if the granodiorite were universal, then it must show substantial variation in thickness. Given any reasonable combination of contrasts, a thickness range of 500 m to 4 km is likely; the higher figure being possible only if the granodiorite were universal. The relief of up to 2 km, as shown in the original interpretation would still be required.

e.g.	*Mathinna Beds*	*Granodiorite*	*Basement*	*Resultant* ($\mu m/s^2$)
	ρ = 2.64, t = 5 km	ρ = 2.70, t = 2 km	ρ = 2.67	- 36
	t = 5 km	t = 0 km		- 60
	ρ = 2.60, t = 5 km	t = 0 km		-120
	t = 5 km	t = 2 km		- 96
	t = 5 km	t = 4 km		- 72
	ρ = 2.64, t = 5 km	t = 4 km		- 12
	t = 1 km	t = 4 km		+ 36
	t = 2 km	t = 3 km		+ 12

Consideration of the above table will give an indication of feasible structures, given that the observed range of anomalies is - 33 to + 40 $\mu m/s^2$. Given a section of finite thickness, say 5 km, then not more than 4 km may be granodiorite. Obviously thicker, light accumulations permit more to be inserted, but such accumulations lacking granodiorite elsewhere become unrealistically negative.

Question 9. Section AB of Leaman, Symonds and Shirley (1973)

(a) What evidence is there for dolerite in the block nearest Port Sorell?
(b) What effect does variation of Permian thickness have on the profiles?
(c) How good is the evidence for the Dazzler Range overthrust?
(d) Could the anomalies between Port Sorell and the Dazzler Range be accounted for by a simple syncline of Cambrian materials?

Answer 9.

(a) The fault shown at the word "PORT" extends north-south along the western side of Port Sorell. Dolerite is exposed in a string of residuals adjacent to the west side of this structure. The Tertiary cover is clearly extremely variable in this area and only an average approximation appears in the section.

(b) Variation of the Permian component is insignificant; 100 m = 4 $\mu m/sec^2$ or 0.4 mgal.

(c, d) These two questions will be answered together as much of the relevant discussion is common.

The gravity anomaly east of Port Sorell is such that at least 2.4 km of Cambrian rocks must be present. If there is no extension eastward as shown in section AB, then this thickness must be raised to at least 3 km. If the anomaly were accounted for by a single synclinal form with the eastern side at the Dazzler Range Front then the eastern side must show near vertical dips (it does) and extend to more than 3.5 km.

The evidence for an overthrust attaches to the lack of coherent gradients to be expected from the structure described above and the general spread of positive anomalies across the Range. Examination of the residual anomalies shows a bifurcation in the lateral gradient, one arm passing across the Dazzler Range. As neither the Beaconsfield or Frankford mapping has detected any variation in the Precambrian rocks which could provide suitable density contrasts, it must be concluded that Cambrian material is underthrust.

Density determinations at Badger Head would be necessary before any revision of the existing interpretation could be justified. It must be noted that a model comprising both thrust and Port Sorell syncline is certainly a possibility.

Question 10. Section BC of Leaman, Symonds and Shirley (1973)

(a) attitude and thickness of Cambrian rocks west of Beaconsfield?
(b) effect on section of dolerite, Permian errors?
(c) dolerite feeder at fault?

Answer 10.

(a) Cambrian rocks were shown to overlie the Dazzler Range materials on the basis of the best available evidence. A substantial thickness is implied adjacent to the boundary by a +4 mgal anomaly. Hence the first block from the Dazzler Range showed a steep junction.

(b) Variations in the thickness of Permian rocks are relatively unimportant gravimetrically. A reduction of 200 m being equivalent to +0.8 mgal. Thus removal of about 90 m of dolerite from the section would leave the resultant profile unchanged. If more dolerite occurred beneath the sediments of the Tamar graben, then the effect of say 200 m of dolerite could be counter-balanced by 70 m of Tertiary sediment. Until some independent control is available, the literal reading of these interpretations should be avoided.

(c) The dolerite feeder west of the River Tamar could well have been intruded along the fault indicated. The broken line (model 3) implies this.

REFERENCES

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