Initial inspection of all data now available suggests that many shallow, or surface, structures are related to deeper features and may represent serial rejuvenation. Several elements and boundaries have been examined by on-ground inspection in order to assess the nature and history of displacements, contacts or the presence of multiple intrusions. Multiples are known to occur in the region (e.g., Hunterston 1) and in escarpments at Liffey Bluff (along seismic line TB01-TH, sp 1300) and may lead to variations in dolerite thickness, transgression and source patterns. Corrections and assessment of such variables must be included in both the depth analysis, and feedstock for test by potential field methods.

Each seismic line has been reviewed. This approach may be contrasted with the 1991 interpretation which used a net of gravity and magnetic profiles extracted from the data base. No seismic correlation was then available. However, since the seismic lines are not straight traverses, the assessed profiles have either been segmented or selected to approximate the location of the seismic lines. Character projections have been made based on indicated, exposed geology. Preliminary geological sections were then generated using inferences about intrusion forms, stratigraphic setting and dilational patterns and faults. Such sections may depend on decisions about, and information of, intrusion multiples and the direction of intrusion: factors which usually requires direct inspection. Not all critical sites have yet been visited. Gravity and magnetic modelling may then be applied to test consistency, or existence of paradoxes and alternatives. Such alternatives are almost never crucial for interpretation of gravity-magnetic data at upper crustal scale since the details of any structures within the Parmeener cover tend to be gravimetrically trivial in comparison. *The bulk of the gravity field responses are generated beneath the base Permian unconformity.* An understanding of the cover section is, however, relevant to interpretation of the more obscure parts of the seismic records and more reliable time depth estimates for other parts.

There are some limitations upon the various contributions and features assessed. All structures, and at all scales, are three dimensional. The layout of currently available seismic lines rarely permits any such view. Exceptions are very local to Hunterston, Bronte and perhaps Bellevue. Further, the surface structures, especially those involving dolerite, are also three dimensional. This is particularly critical in the case of magnetic data, especially where the data are controlled only on widely spaced lines. Consequently, any potential field profile based on 2D analysis may only provide an indication of structure or sequence. There is, however, no reasonable case for 3D analysis: something which can only be justified when the implications of 2D studies have been fully appraised and controlled by some relevant drilling. Not enough is known about any part of the region at this stage and the available geophysical data sets are not of sufficient quality or distribution to permit such refinements.

Caveat

The present interpretation is thus a second pass of existing data. The first pass (1989-1991) was based only on indicated geological trends and potential field data. This new study incorporates seismic constraints, where any can be distinguished, even though the source of the reflector is not seismically identifiable. **The aim, here, is to use the other data sets to suggest the nature of lithologies and structures recognised seismically.**

It will be evident that any inferences must be simply that, inferences, pending further seismic coverage and well testing.

This study was thus designed to review the alternative explanations for both seismic features and, particularly, gravity anomalies. Magnetic information, such as it is, has been used to constrain or check any aspect which has magnetic character. The deductions offered may be used to define potential targets for further seismic coverage or to locate critical sites worthy of drilling for either direct prospecting value or critical stratigraphic control.

The acquisition of relevant well information, further general seismic coverage, and better coverage of gravity and magnetic data will allow review and revision of the present interpretation with direct application to target focus.

INTERPRETATION

As noted in Introduction this interpretation was begun with a major review of all previous interpretations, even though the basic data available had changed little. Methodology and assessment of factors which make for more reliable judgments have been evolved (Leaman, 1994) and the regional and sketchy nature of the early interpretations involved under-sampling of the existing data. For this study, the existing data has been sampled to its limit of reliability or definition and this has led to more detailed and comprehensive analyses – if far from satisfactory. The interpretations have also been polished and completed, and tested with alternatives suggested by the experience of basement studies undertaken elsewhere in Tasmania since 1991.

REGIONAL LINES 3 AND 7

Two examples of the review of the 1991 interpretation are presented here: for lines 3 and 7. In each case emphasis is placed on the style or content of basement contributions. These lines were used for regional indications and no detail is included for the Parmeener cover: that is included in the models which relate to the seismic traverses.

Line 3 is oriented WSW to ENE and extends from near Philips Lookout west of the Gordon River, to the Derwent River at Wayatinah, to Dungrove Hill near Hunterston, to Woodbury and ending on the eastern side of the Eastern Highlands north of Swansea. Coordinates on traverse: 441 000 mE, 5301 000 mN; 500 000 mE, 5319 000 mN; 540 000 mE, 5331 000 mN; 576 000 mE, 5342 000 mN.
Line 7 is oriented NW to SE and extends from Clumner Bluff above the Mersey River to Lake Fanny (447 000 mE, 5366 000 mN), to north end of Lake Echo (470 000 mE, 5340 000 mN), to west of Hunterston (497 000 mE, 5309 000 mN), to Bagdad and ending at the head of Pittwater, at Horatio Point.
These two lines sample and integrate the implications of all previous work and each has been recalculated with new data sampling, and with gravity data in residual form.

LINE 3 provides a true dip line across the multitude of structures inferred in earlier interpretations (see Figures 4 and 5).
Figure 6 presents an interpretation which is directly derived from previous views. Lines such as Line 3 allow some control of the density assumptions included since it extends far enough east to sample the effects of the East Tasmanian batholiths (Leaman & Richardson, 1989a, 1992). The density of these lithologies is well established and can be used to provide constraints elsewhere in the model. Only the depth to granite may be uncertainly defined. This model also suggests the minimum thickness of the Parmeener cover but other models, as shown below, thicken this cover – depending on the number of dolerite intrusions involved. The gravity model extends the exposed Lower Palaeozoic folded section to the easting of Wayatinah. Major changes occur at this easting and this combination of rocks cannot continue. A large volume of relatively dense material must be introduced (a dense variant of Precambrian basement – approx 2.72-2.74 t/m^3). This core block, which generates the relatively positive gravity field character across much of central Tasmania, tapers eastward.

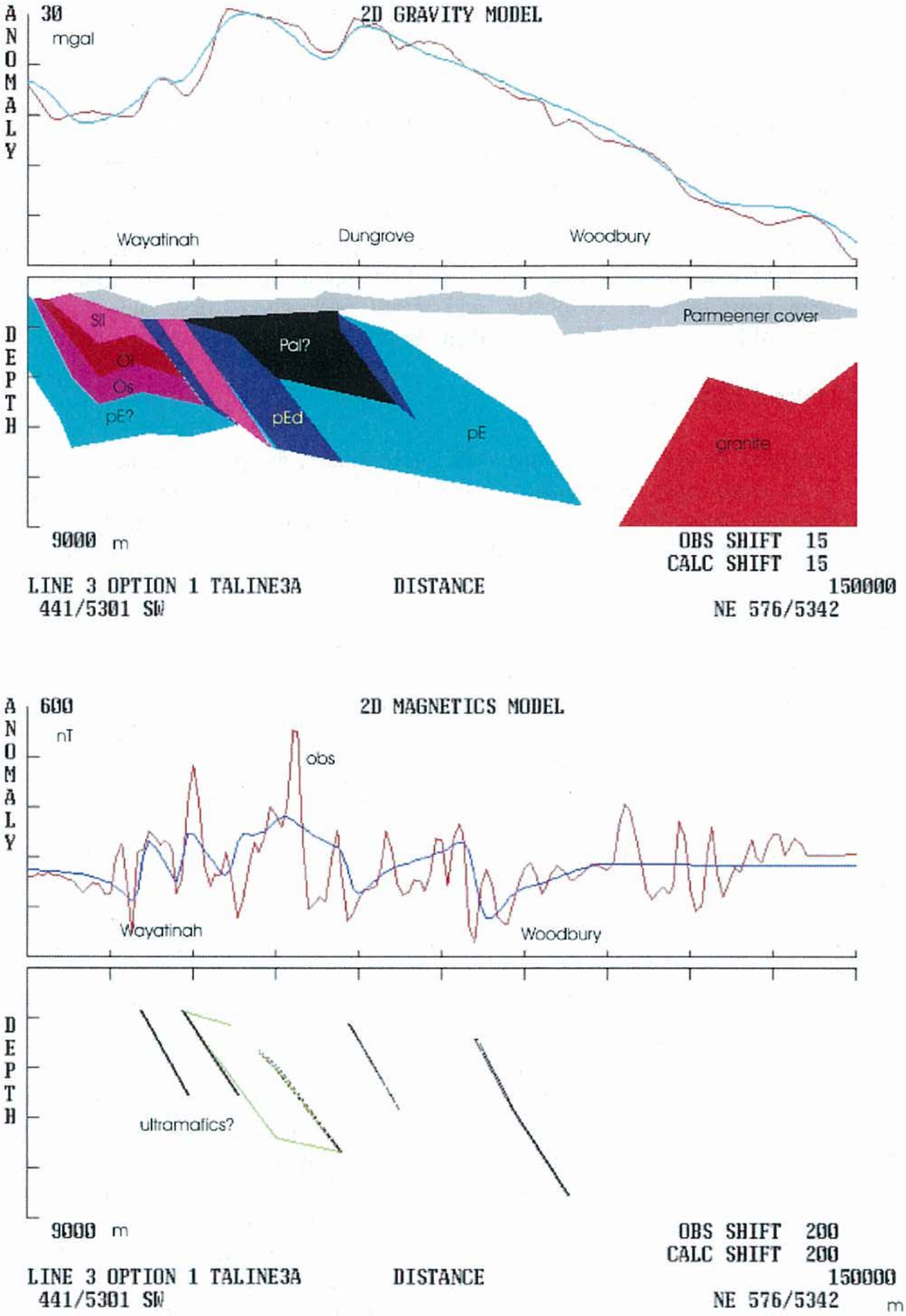

Figure 6 East dipping multi-thrust concept. Line 3 potential field model.

Basement materials in the eastern half of the section must be dominated by siliceous rocks or suites comparable to the Mathinna Beds. Granites control the east end of the gravity profile. Two other lower density sequences can also be inferred. The first occurs as a structural (?) slice beneath Wayatinah, the other just west of Dungrove-Hunterston. This material (labelled Pal?) is almost certainly some combination of Ordovician-Silurian rocks dominated by siliceous members. Although there is no seismic control for this profile there is seismic evidence for this interpretation (discussed below for Line TB01-PB, part 1, Figure 12). The model cannot resolve whether these rocks simply overlie basement rocks or are structurally emplaced.
A test of the east-facing multithrust concept, and the issue of structural emplacement, can be provided by magnetic data. The deficiencies in the present data set are immediately evident. It is not possible to completely separate the effects of "noise" due to near surface dolerite, or dolerite feeders, and deeper sources, but there are gross features which can only be explained for when deep, narrow, intense sources are incorporated in the model. Such sources, in a Tasmanian context, are almost certainly Cambrian ultramafics and structurally emplaced. The models of Figure 6 would suggest that any component of Lower Palaeozoic rocks within the section east of Wayatinah has been structurally emplaced.

Figure 7 considers the implications of seismic sections such as TB02-BA and TB01-TB, TH (see below, Figures 10, 17, 21) that structures dip to the west in the western part of the region. This option was never considered in previous work due to time constraints, and the incomplete nature of the studies, although other work in western Tasmania (e.g., Leaman, 1986; Leaman, 1992) had revealed a preponderance of west-dipping structures, overprinted by east-dipping structures. Figure 7 not only shows that the available data support such a view, but that it is more likely. Note especially the magnetic model. Both parts of the model make clear that virtually all major relationships between units are structurally controlled.

Hole Hunterston-1 can be located in this framework. It was drilled just east of the slice of presumed Lower Palaeozoic rocks (black in Figure 7) and into the denser Precambrian core block sequence. This basement composition had been largely predicted by Leaman (1991, 1992) but considered more massive dolomite, rather than a dolomitic association, as here implied.

LINE 7 samples the entire core zone of central Tasmania and intersects Line 3 about mid section (at 90 km). There are limitations on the density range which can be applied to the basement core but all packages in the northwest appear to dip west while those at the southeast end of the section dip east. The wedged character of the core is re-inforced with this orientation and the cause is probably due to offset thrust blocks. A lower density zone has been located southeast of Waddamana.
Various options are possible for block dip, volume and mass on the basis of gravity data alone. Magnetic data are, however, sufficient to separate alternatives and support the particular gravity solution offered. Ultramafics are involved along at least three of the major boundaries or contacts inferred and those west of Waddamana may only dip westward. The wedge of undifferentiated Lower Palaeozoic rocks, with densities consistent with Silurian and perhaps Devonian (?) rocks, or extremely thick Permian tillites (most unlikely), are bounded by an east-dipping structure and rejuvenations.

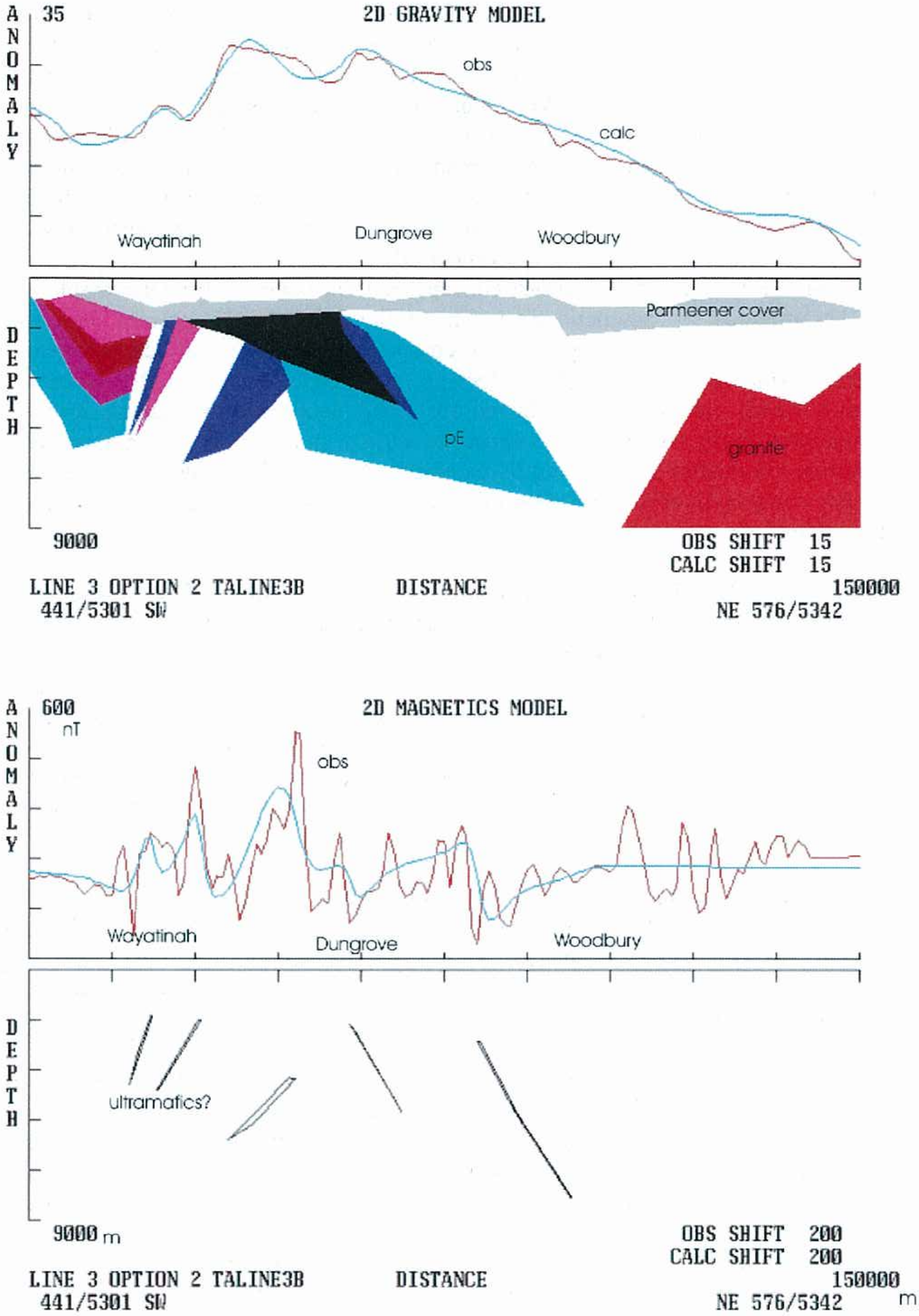

Figure 7. Opposing thrust concept. Line 3 potential field interpretation.

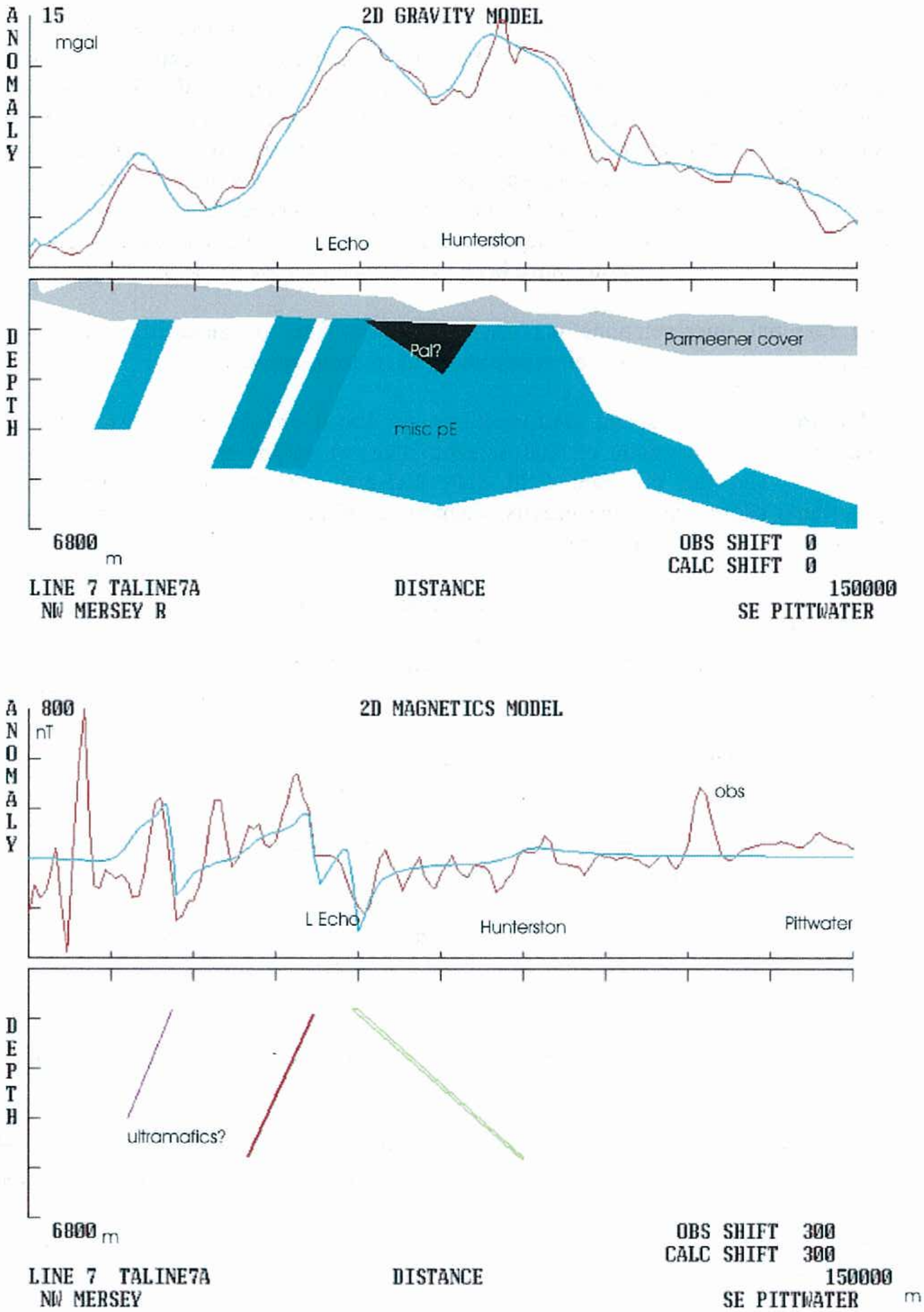

Figure 8. Line 7. Opposing thrust stack concept. Potential field interpretation.

Note that all profiles modelled for lines 3 and 7 display minor oscillations (+/- 1 mgal, +/- 100 to 200 nT) which can be ascribed to data imperfections (gaps, poor definition, errors) or near surface effects such as the local characteristics of dolerite intrusions. Few of these have been examined in detail since close inspection of outcrops and much better magnetic data are required to make sense of the variations. More precise gravity models of the Parmeener section may also be developed when this is possible. It would be possible to present perfect fits for the model and observed field calculations but this would not guarantee their efficacy or reliability in the present circumstances. Gross effects only, as guide sections, have been established in these models.

The regional interpretations may be considered free, or unconstrained, since no independent structural constraints can be, or have been, applied.

All following sections and interpretations are based on observed seismic lines and combine the implications of that seismic data, in so far as useful detail may be discerned, and the potential field data. Seismic data can offer some structural constraints additional to the gravity-magnetic combination and suggest more precise location of structural boundaries.

It must also be noted that the seismic results are far from perfect, clear or definitive and rarely able to provide continuity of features. These deficiencies result from the very high velocities involved, the lack of contrast between velocities, the steepness of structures and the presence of major structures off, but near, traverse. Diffraction and sideswipe effects are very common – as might be expected given the implications of the regional potential field interpretations (Figures 4, 5, 6, 7, 8).

The objective of this integrated interpretation has been to place some scaling on blocks of material, thereby to constrain the physical property range, and allow inference about composition or lithology and, perhaps, age.

The order of lines, as presented, is generally north to south then west in order to provide a linked, systematic view from what is a skeleton coverage.

Seismic LINE TB02-AA2 (2006).
This traverse extends along the Strickland Road from the Lyell Highway north of Ouse (472/53011) to Duckhole Lagoons north of Strickland (4717/5312).

This data set is isolated from other existing seismic traverses and can only be linked to them via regional Line 3 at the northern end of the survey. A consistent solution is shown in Figure 9. The tie point with Line 3 involves the inferred mixed Lower Palaeozoic package some 2 km thick overlying several km of dolomitic sequence (presumably Precambrian). More siliceous Precambrian rocks occur nearby (beneath).

The basic model includes the Parmeener cover, with dolerite, possible Silurian and Ordovician sequences and then the Precambrian base. The white colour indicates generally siliceous Tyennan-type basement. Comparison of Figure 9 with Figures 6 or 7 reveals an excessive thickness of denser Precambrian types. It should be noted that these are relatively dense (2.84 gm/cc) and that their replacement with lower density

Precambrian or Cambrian, Ordovician limestone, units would compound the problems and require a thicker section. The thicknesses suggested are compatible with seismic data and velocities.

The seismic section clearly reveals dolerite within the sequence and the base Parmeener unconformity lies some 300 ms deeper. The deeper section, below this, includes at least three relatively flat-lying reflecting boundaries. The first of these is of the order of 2000 m below the Parmeener cover.

Since the regional solutions are tied to granite densities which are tightly constrained, and set in a much lower Precambrian density framework this section presents a problem. The paradox is almost certainly due to three dimensional features assessed using two dimensional methods and sampling (all data: seismic, gravity and magnetic). The problem develops near the cross tie position (with Line 3) since the remainder of the model is consistent with the rest of Line 3. Note that Line 3, on the basis of all that is known of structural trends, is a dip line: AA2 is a strike line (at least approximately) and may not represent features reliably.

Complete resolution of the issues posed by this line fragment may not be resolved until the line is extended (as planned), nor until a cross line can be observed which ties both AA2, PB and any other new traverses along the Lyell Highway.
Magnetic data do, however, provide an interesting test by suggesting the existence of an ultramafic slice within the dense Precambian segment. This depth, within a few hundred metres, is quite consistent with the structural boundaries implied along Line 3. the magnetic profile has a most distinctive form: it is a step anomaly of long wavelength and cannot be explained by any near surface materials (basalt or dolerite) or shallow structures. Such elements generate the "noise" on the profile. High contrast magnetic materials at moderate depth are required to account for this profile. The subhorizontal nature of the causative body indicates a structure whose strike virtually parallels the model section.

Line 3 model B (Figure 7) stresses the crucial setting of Strickland. Model B is the preferred solution and it suggests the tangle of basement structures which underlie the Strickland area: many of which involve ultramafics.

Shallow structures involving the Parmeener cover are much simpler. All data indicate one dolerite sheet within the section but this sheet passes to an unroofed plug form south of Strickland. Seismic data resolve most of the dolerite character along this short traverse but only patchily define the base of the cover sequence.

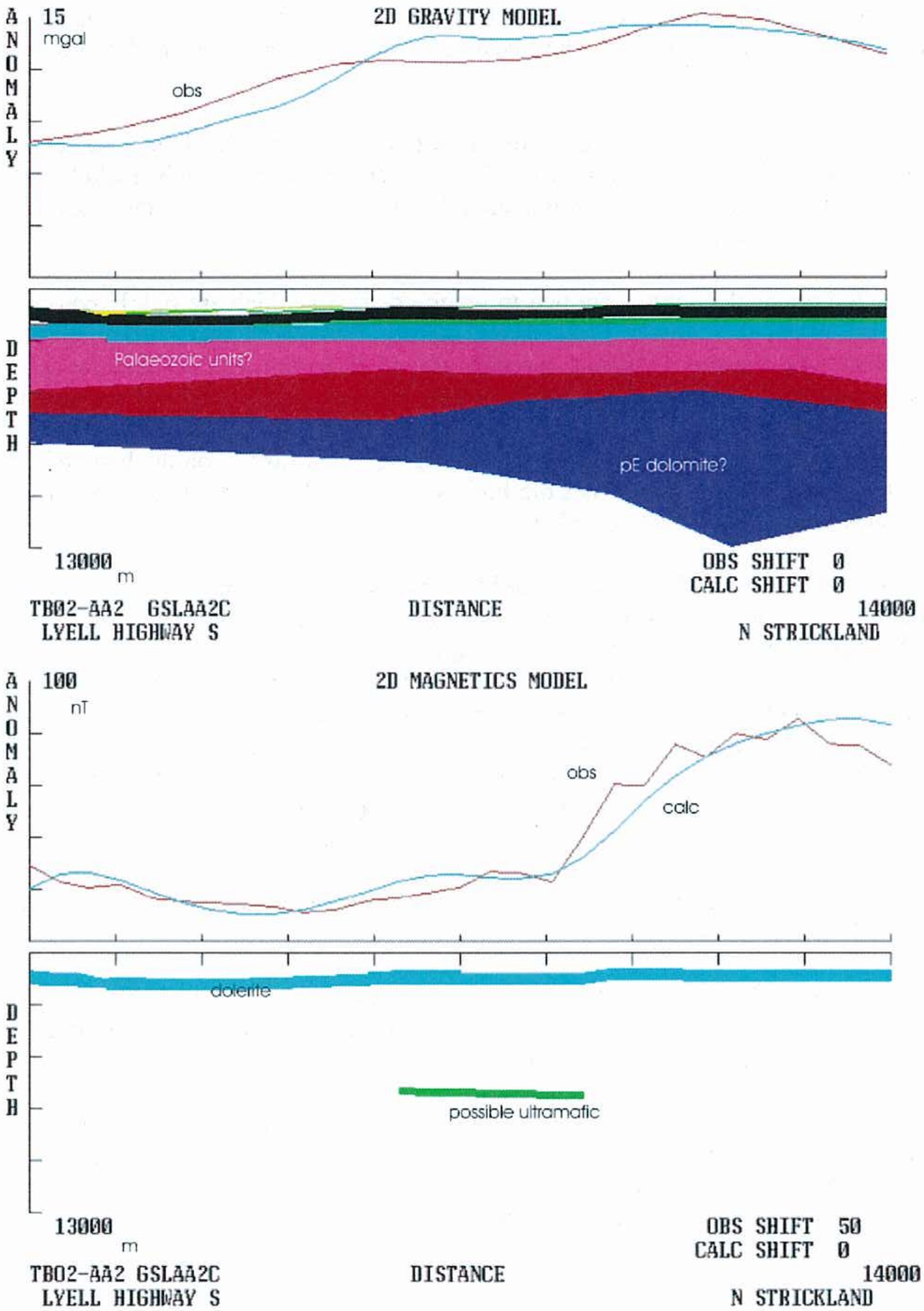

Figure 9. Possible structuring consistent with seismic profile TB02-AA2.

Seismic LINE TB02-BA (2006).

Line BA extends from the Tiger Range above the Gordon River (450/5201), where there was some redundant acquisition which did not assist profiling, migration or correction, to the central plateau and terminates northeast of Great Lake at the very edge of the Great Western Tiers above Poatina (487/5369). The line crosses the topographic ramp onto the plateau. Refer to Figure 10. This line begins on the exposed Lower Palaeozoic rocks of interest to Great South Land Minerals Limited – in the Florentine Valley region.

Both regional control lines intersect this traverse (at about 44 and 77 km; lines 3 (42 km) and 7 (65 km) respectively). No difficulty was experienced correlating the few seismic features observed and the implications of the potential field data. Thus the multiple reflection pattern observed deep in section near Line 7 is probably related to the fault/thrust offset at depth and a similar relationship can be observed near Line 3. North or east-dipping structures are implied consistent with Figure 4. Major steps in the basement complex are implied in all data sets. Magnetic data confirm most of these concepts even though resolution is limited.

Near Line PB (at 85 kim), where Palaeozoic rocks are inferred beneath Parmeener cover, magnetic data indicate that the south face of the sequence is either deposited on and old, thrust surface, on exposed ultramafics, or has been thrust subsequently. Each option is possible and all have been observed, somewhere, in western Tasmania. None of the extant geophysical data can separate these possible solutions. All, however, suggest major basement structuring at various times from the Proterozoic to the Permian (and presumably the Present). The situation is simpler south of the River Derwent. Structural facings oppose and the constitution of the pre Permian basement is quite different. Magnetic data even suggest that part of the basement sequence, thought to be dolomitic on the basis of gravity anomalies, may be magnetic – which would imply equivalents of the Crimson Creek Formation are present. Between shot points 700 and 1600 reflections wedge and dip west. This effect has been reproduced in the models (from 10 to 22 km).

The most distinctive magnetic feature is near Waddamana and may, partly, have a basement origin although there is no suggestion of a density offset. There is a flower-like fan of structures in the seismic record. It is possible for dolerite to account for some of the effect observed and this could be confirmed with more detailed survey. Much of the section north of Ouse contains two dolerites: an irregular sheet base near surface, and a hidden sheet at depth. A feeder may be present south of Native Tier and also north of Waddamana, near Shannon. North of Shannon it appears that only one major sheet is present: exposed. Around the Waddamana area, however, two almost entire sheets intersect and intrude each other. The inter-sheet transgressions are ghosted in the seismic data. Tertiary basalt conceals much of the geometry and alters reflection character. All this structuring, and volcanics, overlie the fan of basement structures which may be hinted seismically.
Long sections of this seismic record are bland and without major event. The implied synformal wedge of Palaeozoic material at the north end of the lien is supported by changes in seismic character and dipping reflections.

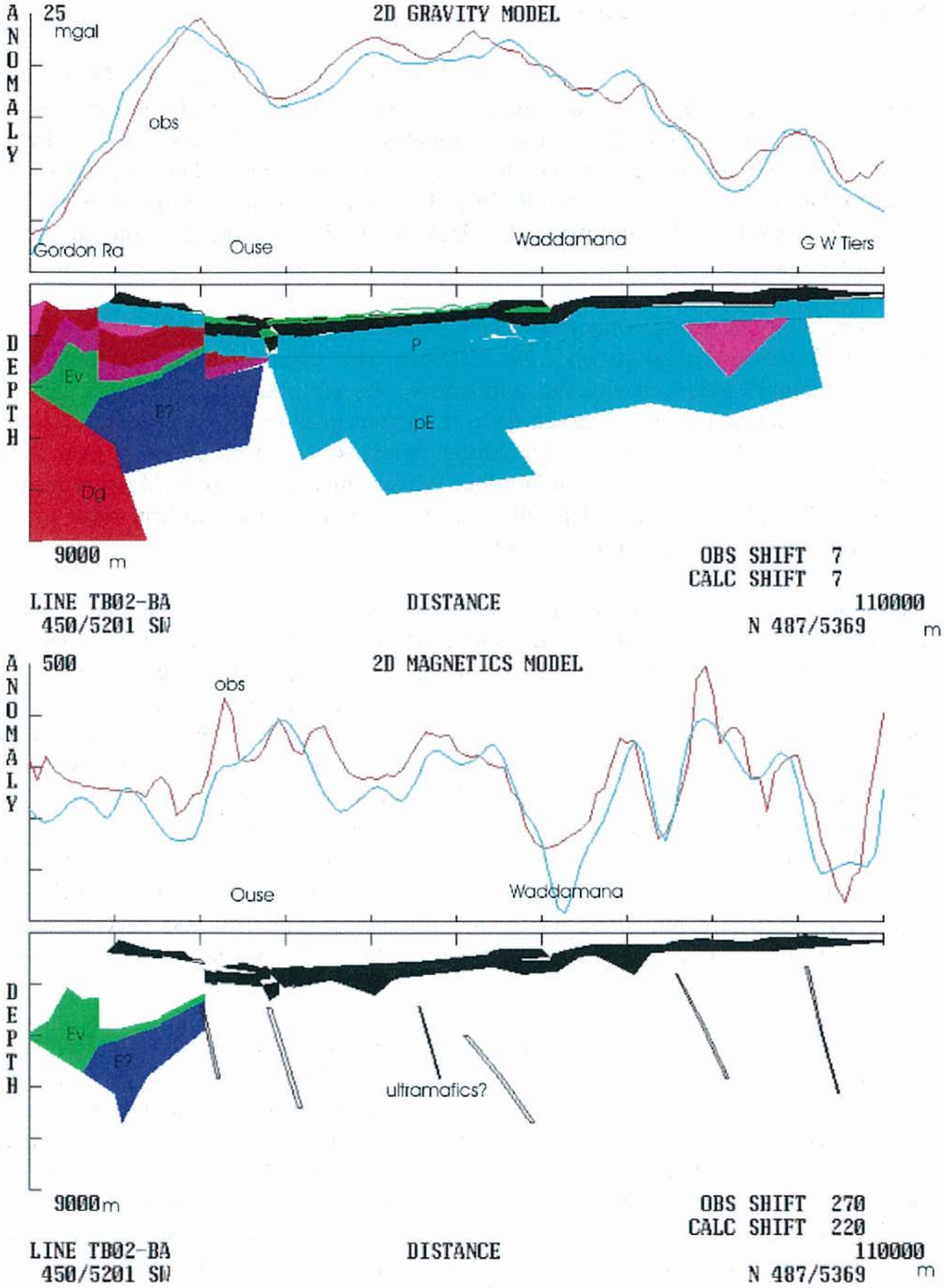

Figure 10. Possible structures consistent with features of seismic line TB02-BA

Seismic LINE TB01-TC (2001).

Seismic line TC extends from the Lyell Highway south of Hamilton (489/52883), to Bothwell (5005/53074), using Hollow Tree Road. Line 7 (at 94 km) intersects this line near Bothwell.

The seismic record indicates up to 6000 m of massive units beneath Hamilton but with a possible shear zone at about 1500 m. The heart of the record includes an apparent arch of reflectors, dipping steeply to the south but more shallowly to the north. Some shallower synformal character is evident south of mid section. The deep record reveals a set of north dipping reflectors.
Various changes in seismic character, and which mark short sections of the line, appear to be related to the zig-zag nature of the traverse with respect to the orientation of deep structures (as inferred and indicated in Figures 4 and 5). No features present with any significant continuity.

The gravity anomaly is distinctive (Figure 11) and requires a considerable thickness of dense material in mid section. This conflicts with the arched reflectors since the depth proportions required of known lithologies cannot account for the anomaly. Matching implications from Line 7 suggests that a slab of Precambrian dolomitic sequence overlies a less dense sequence. These elements can be aligned with the few reflectors observed and account for the gravity field observations at the Bothwell end of the section. The anomaly roll over to the south thus reflects absence of the dolomite but the dominant presence of the moderately dense Precambrian rocks. The uncoloured basement is siliceous Precambrian, probably of Tyennan type.

The observed magnetic field mirrors the gravity field and, given the density links which exclude piles of strongly magnetic volcanics, the solution offered depends on two elements. Two slices of ultramafics, defining the base of the moderate density Precambrian basement and extending into the fan of structures mid section, and granophyric dolerite and feeders, account for the effect. The feeders appear to be slightly off section. The implication from the thrust relationships is that the east-dipping structure is younger but this cannot be confirmed since modest variations in volume and distribution cannot be resolved.

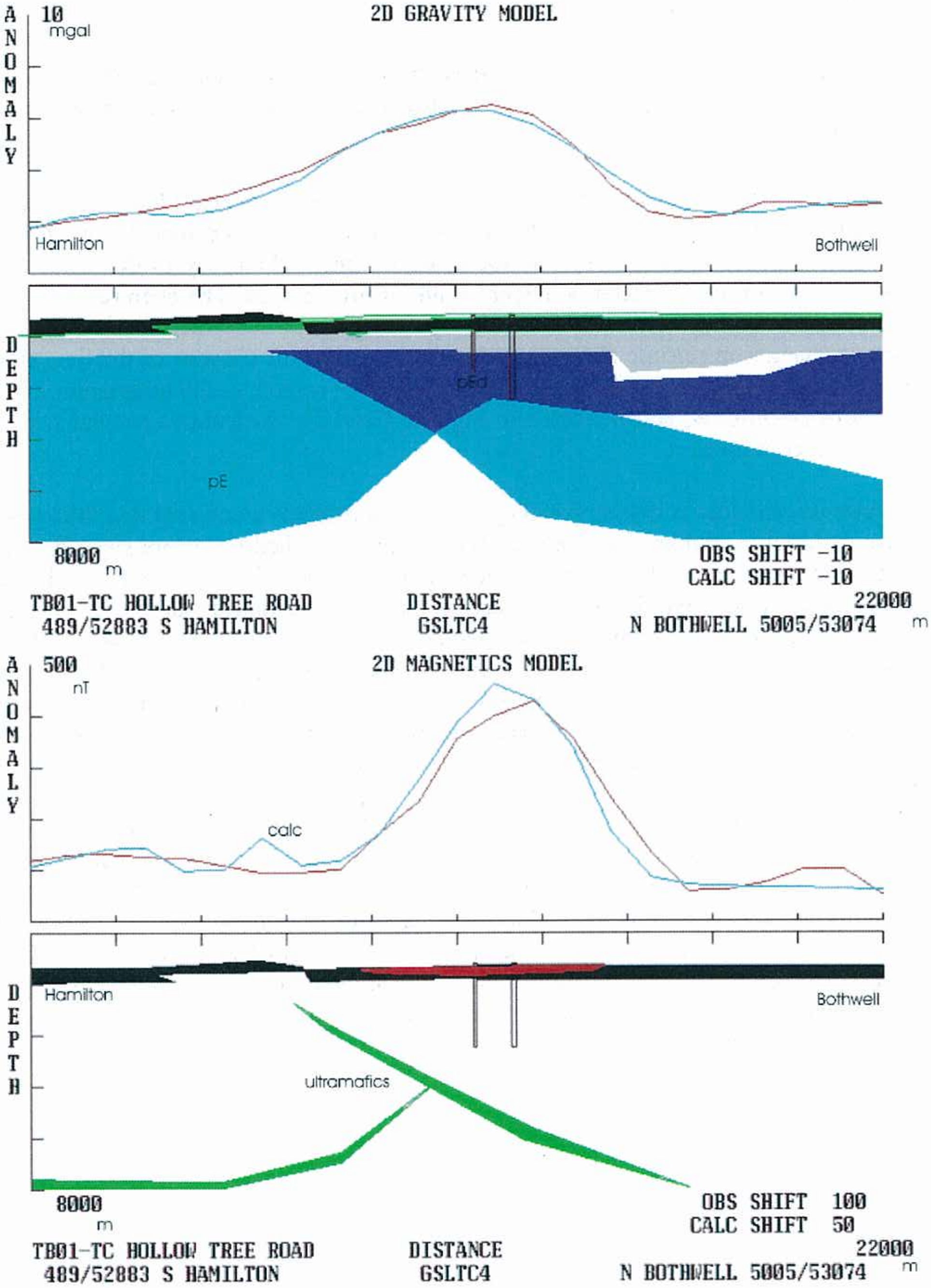

Figure 11: Interpretation of seismic line TC, Hollow Tree Road.

Seismic LINE TB01-PB (2001). Part 1: Bothwell to Steppes.

Line PB is a long, complex traverse and it has been divided into three sections for analysis. Each of these is approximately straight and the segments allow regional linkage free of the total bend in the traverse, or orientation interactions.

The first segment extends from Bothwell (5005/53074) to Steppes (4912/5339) via Highland Lakes Road and Hunterston. This segment can be cross tied to both regional lines (at 10 km to Line 3 at 65 km; at Line 7 at 95 km near Bothwell).
The pre-Parmeener part of the seismic section contains large scale antiformal elements which crest near Hunterston. The antiform is truncated by a ramp reflection at considerable depth (about 5500 m near Lines 3 and 7) and there is an even deeper feature (5000 m deeper). In the region of Steppes there are other shallow reflectors which show strong character (at about 2500-3000 m) and these are truncated by the north limb of the antiform. None of these features are well defined.

Hunterston 1 was drilled near the crest of the antiformal feature and demonstrated the presence of multiple dolerites and a dolomitic basement (pEd). This poses a question about the nature of the rocks above the seismically marked antiform. If the dolomitc content of materials encountered in Hunterston 1 is used to set a minimum contrast for density (2.74 t/m^3) then it is possible to provide an approximate depth match for the deep seismic interface. The density cannot much exceed this value and cannot be as high as pure dolomite (2.84 t/m^3). Constraints may then be set for the amount of this material present toward Steppes. If the upper section is siliceous Precambrian and no more than 2000 m thick (consistent with character-filled seismic zone) then some variation might be allowed in the dolomitic core but a maximum depth of around 7000 m is fixed for the lower surface. A gross fault system is implied.
The Bothwell end of the section is quite different. The Precambrian core is thicker and this can only be mass-balanced by a wedge of lower density rocks (presumed mid Palaeozoic). Beneath Bothwell there are other subhorizontal interfaces and the gravity field requires some dense member (dolomite) to balance the other materials.

These conditions may be summarised in reflection and thickness terms below Parmeener cover.
At Bothwell: reflections at 1500, 3200, 5600, 6800? and 11000 m
Line 7: dense pE to 5000 m and thrust at 4000 m.
At 10 km: reflections <1000, 6500, 11300 m
Line 3: 400 m pE, 800 m pE dense, 2600 Pal?, 6100 dense pE
model: 400 m pE, 800 m pE, 3000 Pal?, 5500 dense pE
Steppes: reflections at 2500-2700 m, 7000-7500 m.

Extant magnetic data are not helpful (Figure 12) since dolerite effects could account for all observations as presently defined. Dolerite along the section involves two intrusions from a feeder presumed to lie offset from Hunterston with transgressions from the south upstepping toward Steppes. The current disposition of the entire sequence re-inforces the effect of regional ramping: ramping due to regional dips and dolerite transgression, both in the same sense (up to north). There is no closure at Hunterston.

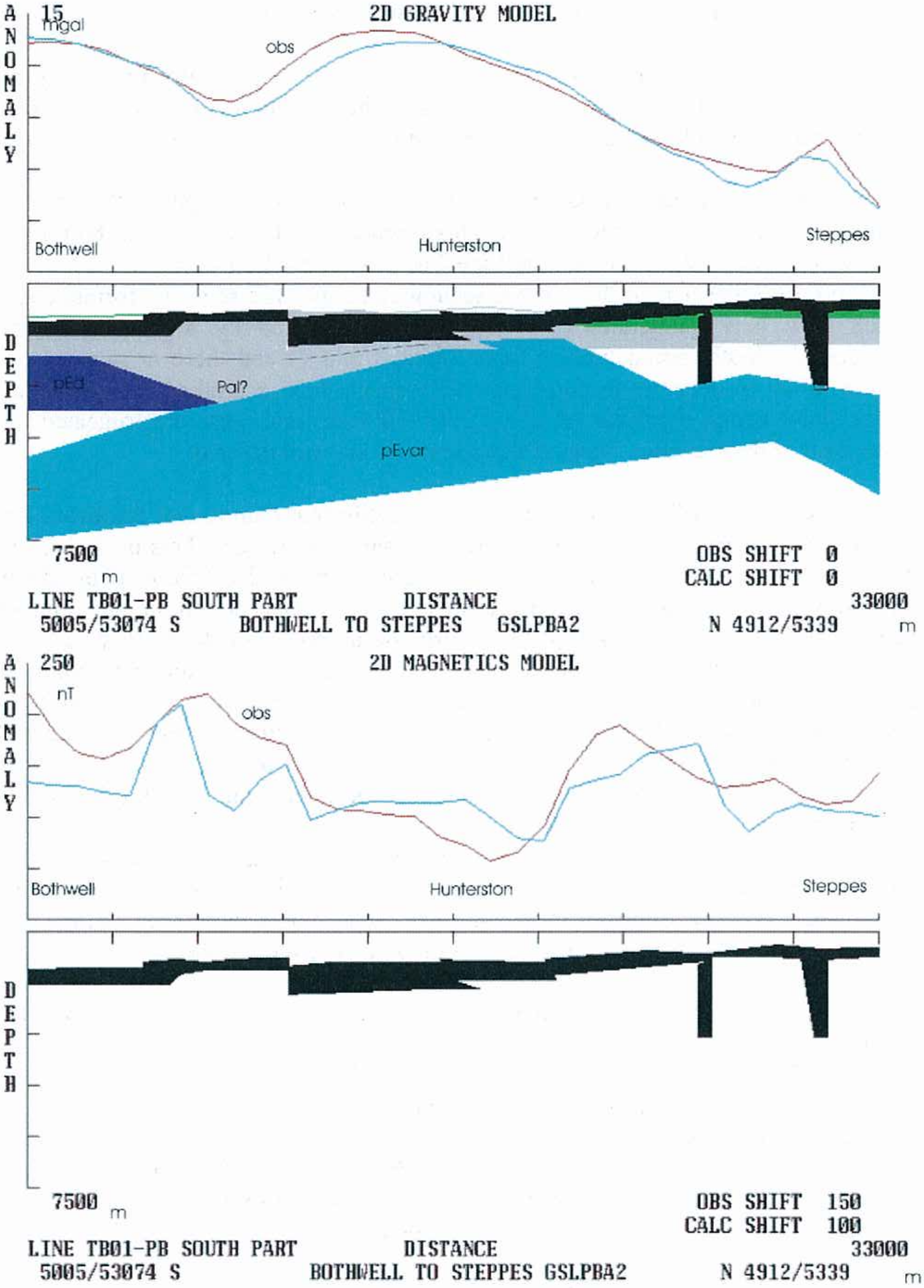

Figure 12. An interpretation of seismic line TB01-PB (first section, to Steppes)

Seismic LINE TB01-PA (2001).

This short traverse provides a cross line on Line PB at north Hunterston and well Hunterston 1 was drilled on this line (4915/5327-4974/53262).
Little seismic character can be discerned below the Parmeener cover, although the dolerite in the section can be identified, until there are transgressions toward the present surface. Character is lost where the dolerite crops out.

The models of Figure 13 provide a reasonably consistent view with Line 7 (nearby to the west) and the intersection with Line PB. The gravity model provides a limiting scale on both density and depth (thickness) of the modestly dolomitic Precambrian core block. The maximum estimate is greater than seen in the longer lines since these also carry the direct effects of denser segments. Some three dimensional elements are not properly represented on this short line.
The magnetic data require the package of Precambrian rocks to be defined by a slice of ultramafic rocks. No concentrated magnetic source, such as Cambrian volcanics or the like, can be involved. The depth to such a slice, which has clearly been sampled acutely to strike at this orientation, cannot be refined without more information but could range from 5000 to 8500 m depending on structure, properties and thickness. This range is consistent with the implications of the longer lines.

Seismic LINE TB02-TA (2001).

This short traverse (Figure 14) extends east from Hermitage across the southern part of the so-called Hunterston dome (4876/53218-4984/53192).

Two steeply dipping reflectors (diffractions?, off line effects) can be identified in the pre-Parmeener seismic section. the most easterly of these may be inferred to lie at about 5500 m at the position of line PB and imply such a thickness of moderately dense Precambrian section. The gravity model is consistent with this and magnetic data support the concept that an ultramafic slice forms the base to the entire core block.
West of the main central block one of the main reflectors seems also to be related to ultramafics. The gravity model would extend this structure to the base of the Parmeener cover but the magnetic data is not able to resolve this detail. The two ultramafic slices can be associated with volumetric offsets in the basement block.

Part of the principal magnetic anomaly is due to near surface variation in the dolerite and a granophyre and, or, feeder, is suspected nearby. Since this location is close to Waddamana Road this inference should be checked.

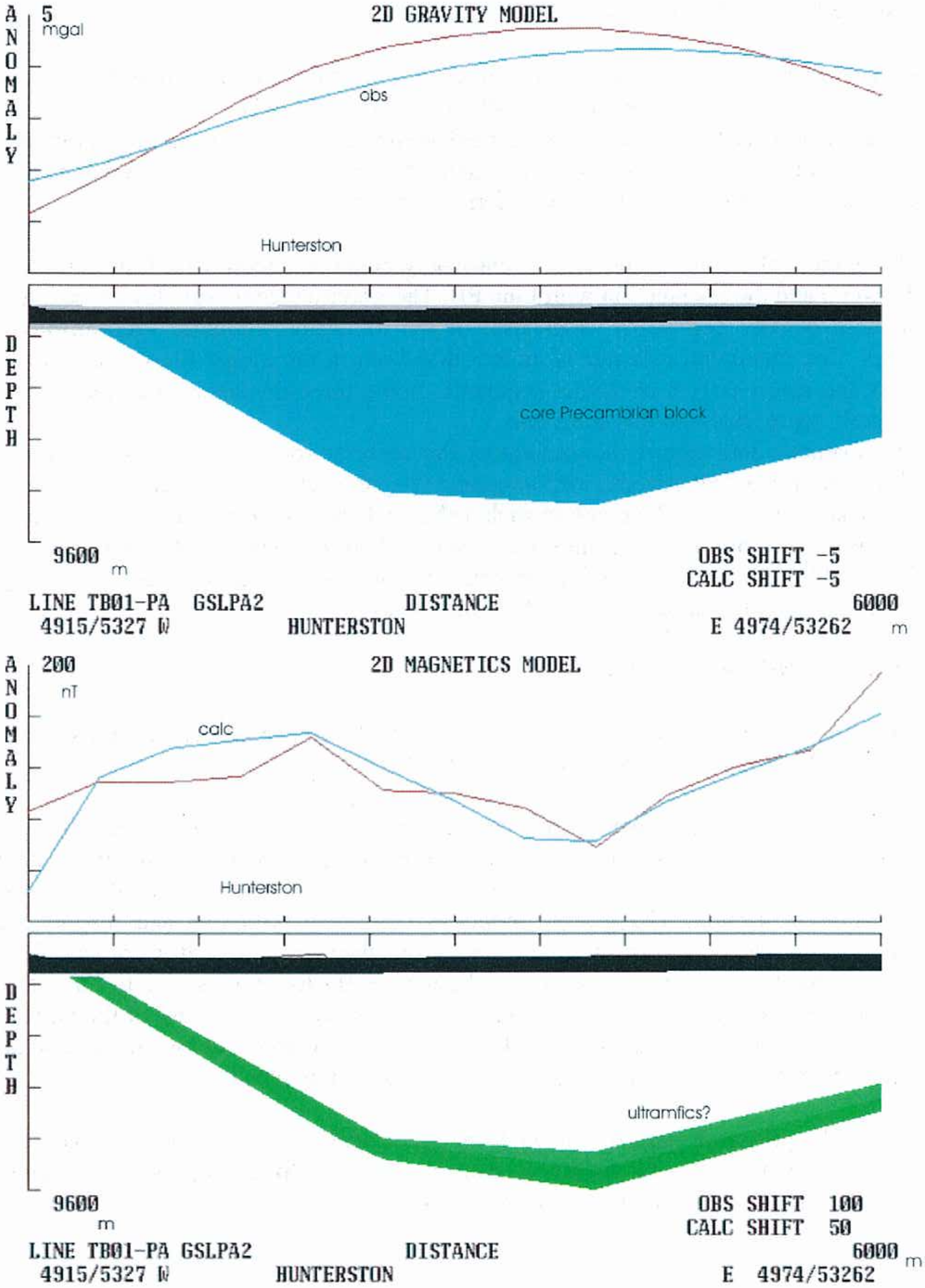

Figure 13. Interpretation of Hunterston cross line, TB01-PA.

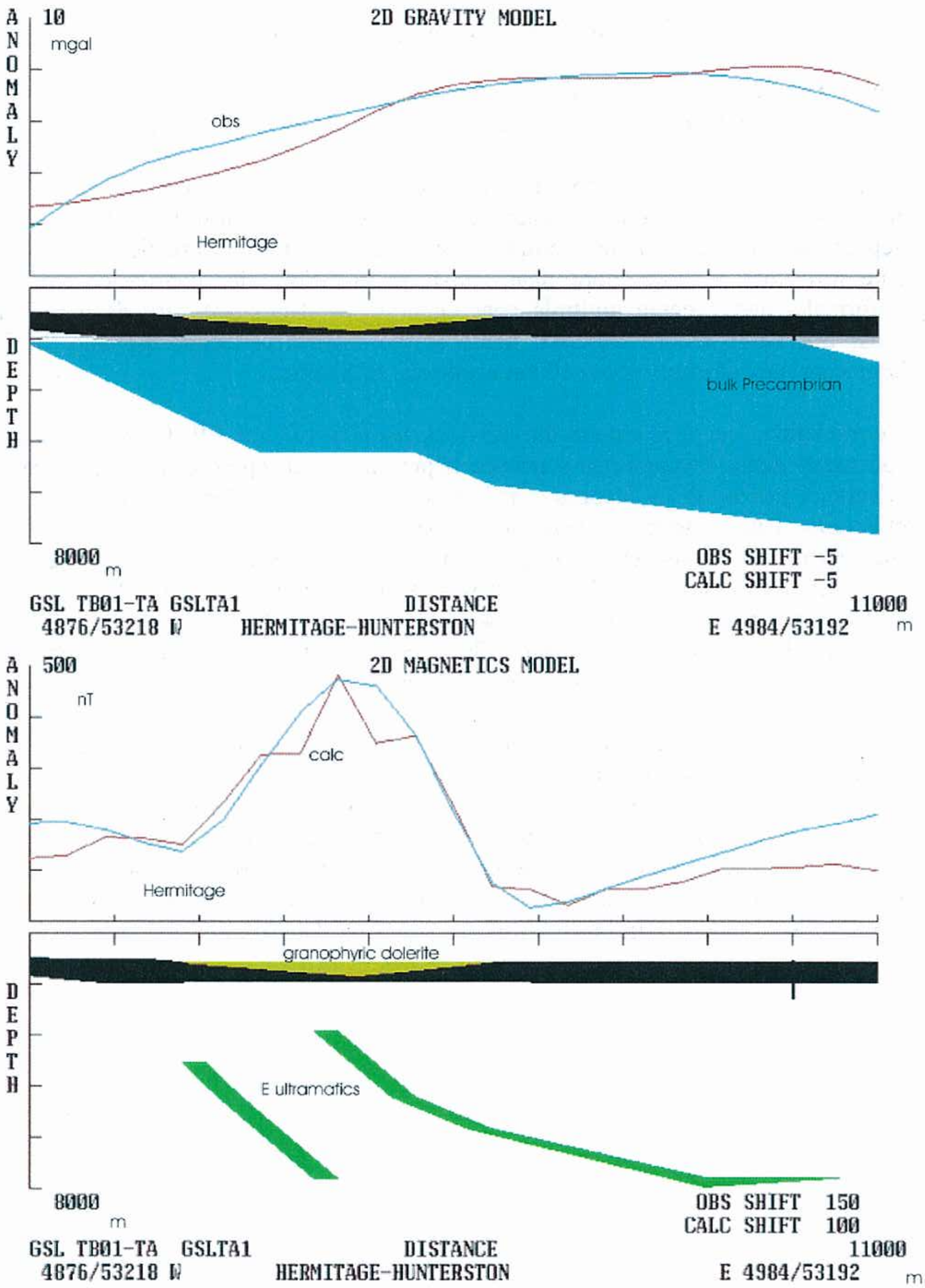

Figure 14. An interpretation of Hermitage cross line, TB01-TA.

Seismic LINE TB01-PB (2001). Part 2: Steppes to Great Lake

This segment of Line PB extends from the road junction at Steppes (4911/53388) to the Marlborough Highway junction at Great Lake (4795/53545).

The portion of the seismic record is marked by two strong reflections which dip south. Other character is very limited. There is a suggestion of a north dipping feature near Steppes and a possible sub horizontal element above it. From mid section toward Great Lake reflectors at little more than 100-1500 m below the Parmeener cover dip synformally and become multiple near Great Lake. There are very deep reflectors across this entire record segment. Some of the shallow reflectors dip into the base Parmeener unconformity about 10 km northwest of Steppes.

The modelled structures extend the previous segment of Line PB. On the basis that a moderately dense Precambrian sequence is present – and represented by the wedge of reflections just north of Steppes – it is possible to account for the pattern of major reflections with reasonable consistency across the entire model. The synformal character of reflections approaching Miena can be explained with the presence of mid Palaeozoic rocks, some of which must wedge out about 10 km north of Steppes. The large gravity anomaly near Great Lake is consistent with the presence of a more massive dolomitic sequence and the reflections in this region may represent the upper surface of this block of material. These features are shown in Figure 15.

Magnetic data provide considerable support for the structural interpretation and suggest that the southernmost south-dipping structure contains ultramafics, or the reflection is due to them, and that the other strong reflections – both midsection and near the synform – are also due to the presence of ultramafics. The structure some 4 km south of Miena is comparable with that of the Huskisson Syncline of western Tasmania and the main Precambrian block is also marked by bounding ultramafics on its upper surface. Strong reflections occur in the zone where magnetic data imply the presence of mafic slices.