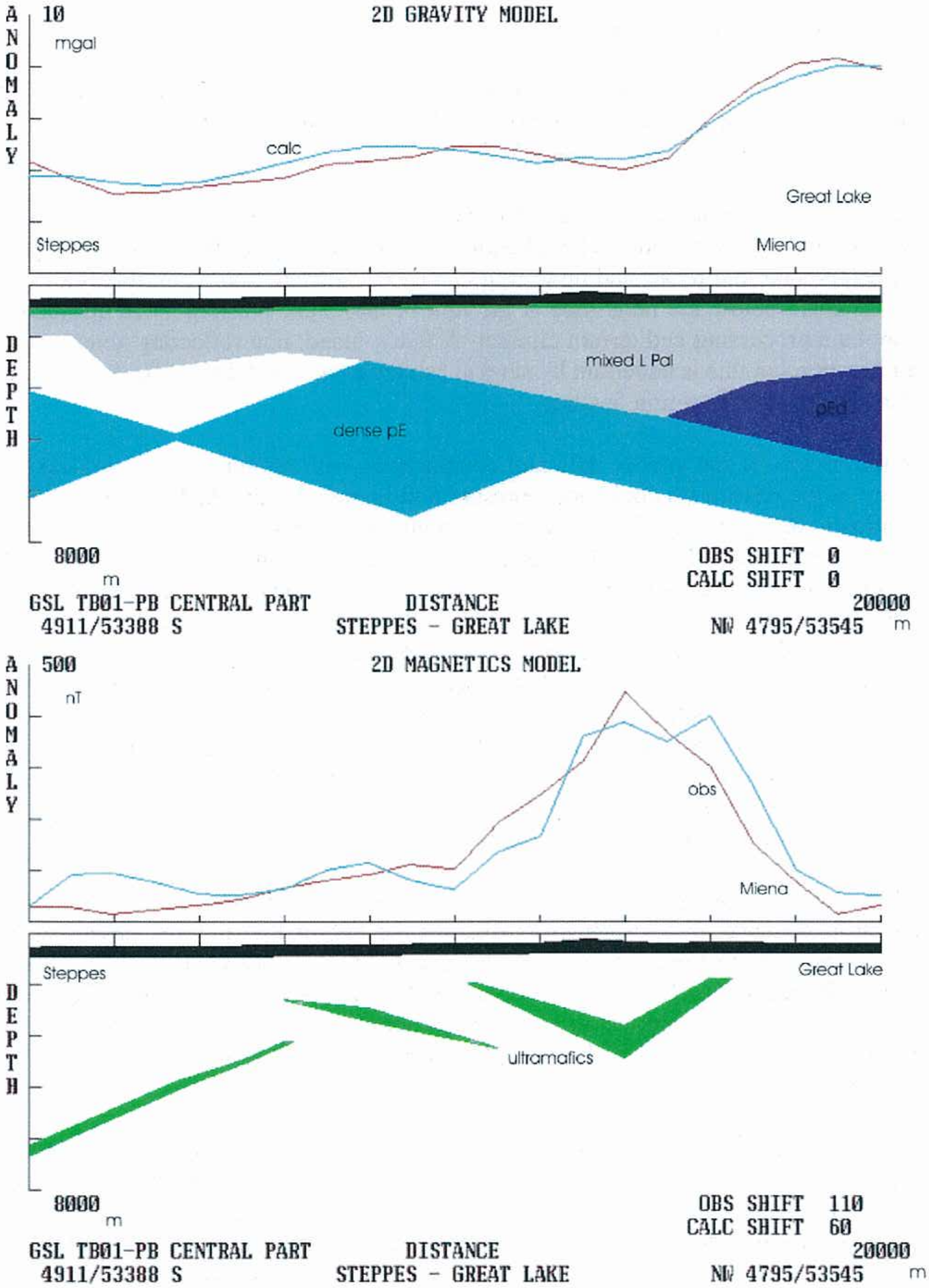

Figure 15. An interpretation of seismic line TB01-PB (Steppes to Great Lake segment)

Seismic LINE TB01-ST (2001).

Seismic line ST extends along Interlaken Road east from the Steppes (4912/53388), down the Tiers escarpment, to Tunbridge (Midland Highway, 53405/533415) to Chapel Hill near the Macquarie River (54205/53335).

Seismic data contain much character. Several interfaces dip steeply eastward from Steppes and appear to unite. The reflections are then disrupted. East of the high plateau reflectors tend to dip east and up to four can be recognised. Some possible folding may be indicated below the fault zone at the foot of the Great Western Tiers but the effect may be a processing and terrain artefact. A thick, bland, non reflecting zone is present mid section but this is underlain by several subhorizontal, and deep reflectors. There are also several out-of-section features.

Initial review of the gravity data and comparisons with regional Line 3 indicated that many of the reflections could not represent unit boundaries at which significant density contrasts were present. Most are clearly structural margins. Since part of the very low gravity field near Chapel Hill is due to batholiths at depth (just off end of section, Figure 16) some constraints may be applied to the possible solutions within the boundaries imposed by the reflectors. The bulk of the gravity field can be satisfied by slabs of moderately dense Precambrian rocks of the type encountered in Hunterston 1. These appear to be thrust-bounded. The sequence appears to include slices of modestly dolomitic material, interspersed with more siliceous rocks. The small positive anomaly near Chapel Hill may be due to a further slice of Precambrian rocks (inserted in the form of the Badger Head thrust block west of the Tamar River) or a denser version of the Mathinna Beds. The lower density sequence (magenta) is inferred to be mid Palaeozoic and is almost certainly Mathinna Beds.

The situation at Steppes is consistent with that inferred on parts 1 and 2 of Line PB, in which a sequence of siliceous rocks overlies the denser Precambrian basement. Both sequences may be Precambrian. A little east of Steppes, however, a segment of low density Palaeozoic rocks may be inferred and these are possibly Silurian or Devonian in age given other correlations. A major offset structure, dipping west extends beneath Steppes, and is the origin of the disruption in all reflection character between SPs 720 and 850.

Magnetic data offer some interesting insights on this profile. Nearly all major blocks appear to be defined by magnetic slices of high magnetisation. Ultramafics are clearly universal. These materials define the base of the main central slab and the top of the western slab. A further slice of mafics appears to lie within the possible Mathinna Beds series beneath Tunbridge but these are not accurately located with the present data and may be situated along the unit boundary inferred gravimetrically. If this is indeed the case then it would suggest that the upper block beneath Chapel Hill could be Precambrian.
The relatively flat-lying deep reflections near SP 1220 probably mark a sheared siliceous sequence beneath the slab of modelled, partly dolomitic Precambrian. East-dipping character then predominates to the east as indicated seismically. All features are either thick or widely separated.

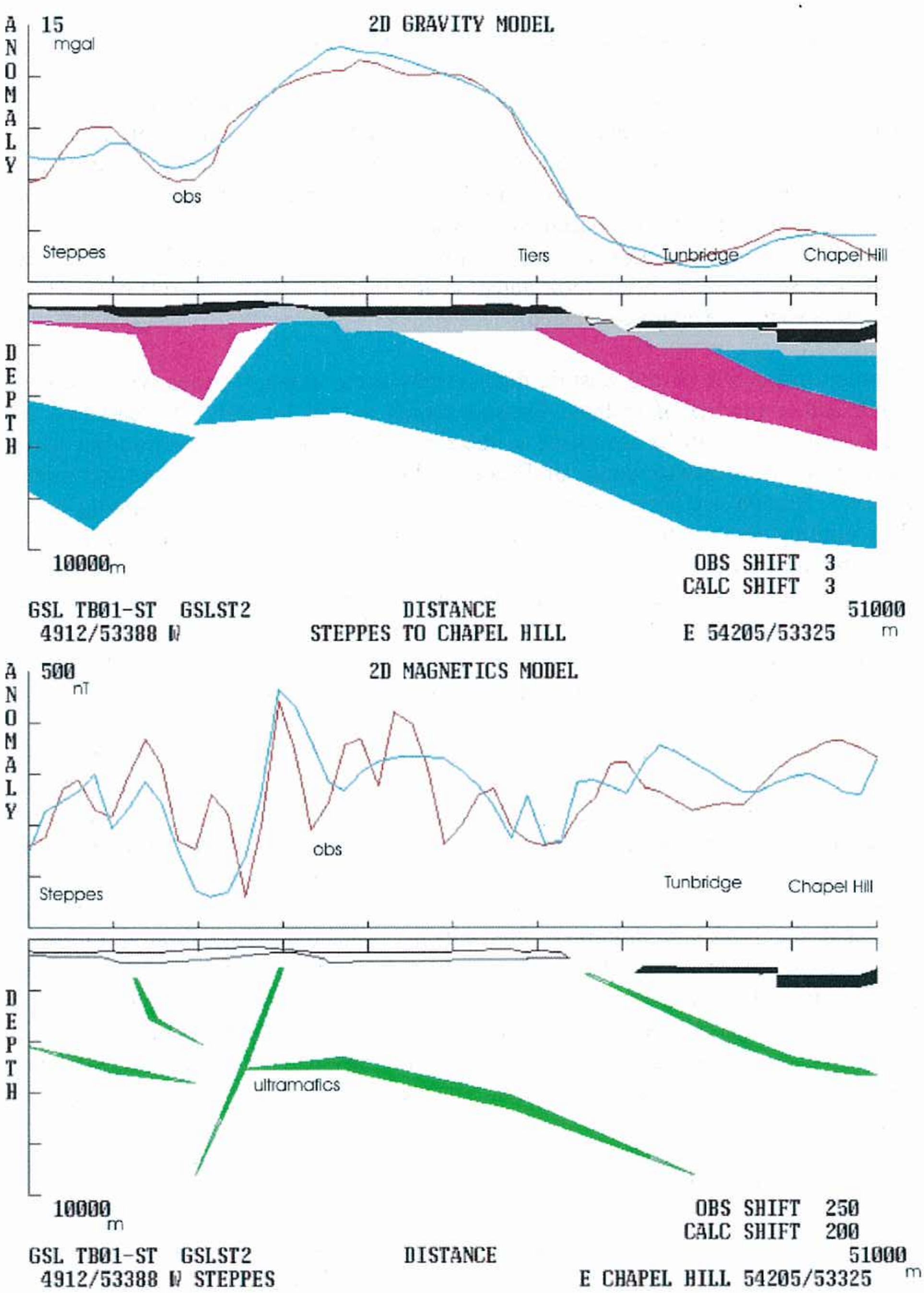

Figure 16. Interpretation for seismic line TB01-ST, Steppes to Chapel Hill.

Seismic LINE TB01-TH (2001). Great Lake to Golden Valley

Seismic Line TH seems to offer an opportunity for considerable control and inspection of the types of reflection event to be expected from exposed Palaeozoic rocks and the Parmeener sequence on the Great Western Tiers. This line presents some of the best seismic data in the surveys to date but the variability of the geology and the uncontrolled nature of the basement possibilities confounds simple assessment. The southern end of the section is at the south end of Great Lake (4733/53521) and the modelled section has been terminated near Golden Valley (4761/5392) where the basement rocks are again concealed.

Detailed inspection of the seismic data reveals some major features with continuity in depth and a number of isolated features which extend laterally. At least two erratic, wavy reflections can be identified at the Great Lake end of the section but there is a large break in character south of Breona. This feature dips northward (or eastward); between Breona and Pine Lake there are some marked events also dipping northeast, then nothing at greater depth. No specific features can be related to the Tiers or the Tiers boundary but there is a nest of both north and south-dipping features beneath the slopes of the Tiers. The principal problem is that none of the many isolated blocks can be directly correlated to any Palaeozoic suite in the section or along strike. The interpretation is thus dependent on the size and shape of the elements recognised and the possible physical properties which are consistent with these.

The common tie for three profiles (TH, PB parts 2 and 3) is along the southern shore of Great Lake and there are simpler and more direct controls from the other lines which link out less ambiguously. The real problem is that the southern part of the traverse is quite different in character from the northern part and the bounding structure is clearly major (Figure 17). Near Great Lake a sequence involving relatively low density Palaeozoic rocks, inferred to be Silurian and, or, Devonian, overlies a dense dolomitic unit and the modestly dolomitic Precambrian basement. The absence of any clear magnetic correlation suggests that the dense unit is a Precambrian dolomite. The large gravity anomaly mid section can only be explained by dolomites since the gradients are critical. The anomaly contrast to the south is striking and cannot be managed within the reflection frame unless the block is relatively low density siliceous material: the obvious candidate is west Tasmanian Silurian rocks. This would then imply major thrust dislocation to also draw in the dolomite above them. The truncation of all these blocks is unusual but there is a ghost of reflection in the required position suggesting another structure cutting into the section.

A more ordered situation can be deduced between Breona and Golden Valley in which a large fold may be mapped. This fold includes a full sequence of Lower Palaeozoic rocks and representatives of all members exposed around the region are included. Gordon Limestone must be included as one of the few positive density agents and generates the low positive bulge in the gravity profile. Note that this is not in the position inferred by Blackburn (2004): that position, with formations wedging up to the unconformity is occupied by probable Silurian rocks.

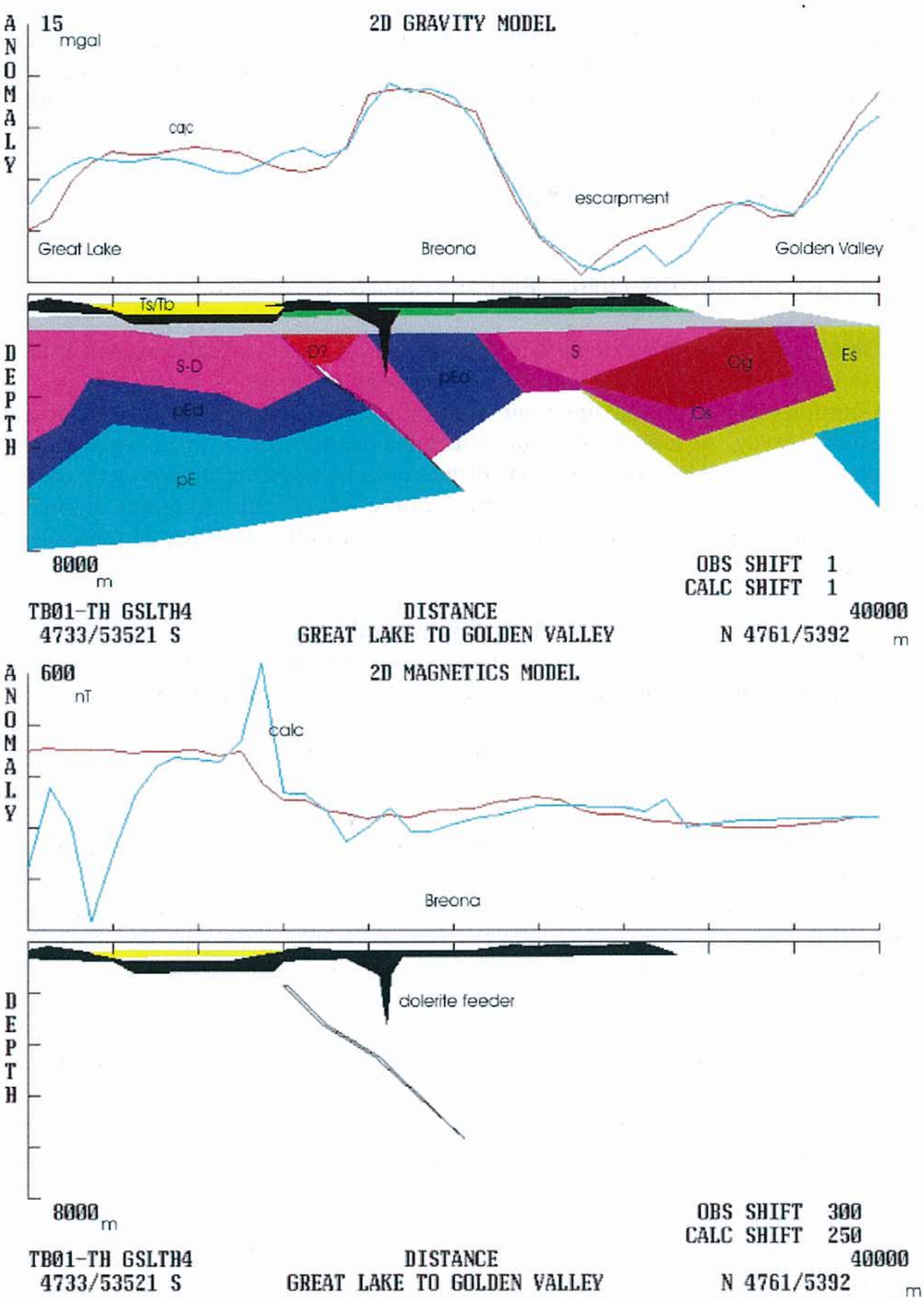

Figure 17. An interpretation of seismic line TB01-TH, Great Lake to Golden Valley.

Magnetic data define ultramafics in the main offset structure. The data are not adequate to fully assess the effect of dolerite, dolerite feeders or basalt at Liaweenee. Gravity data skirt the main dolerite feeder beneath Great Lake and the effect of this feature is to sharpen the crest of the central anomaly.

A dolerite feeder (see McDougall, 1964) has probably used the lower dolomite dislocation surface.

Seismic LINE TB01-PB (2001). Part 3: Bronte to Great Lake

The third part of Line PB extends from Bronte (457/53305) via Bellevue and cross Line TD, to Great Lake (4725/5353) via the Marlborough Highway.
This portion of Line PB contains some of the most interesting and striking reflections in the entire survey. At least four major reflections can be seen in three segments of this portion of the line. Unfortunately none of them can be traced unambiguously across the record but together they present a giant antiform effect with structures dipping both south and north and almost flat-lying in the region of Bellevue. What do these elements represent?

Other lines (PB part 2, and TH) suggest possible Silurian rocks and Precambrian dolomite overlying a modestly dense core of Precambrian rocks. This can be accepted in the present model (Figure 18) but the gravity profile suggests that the Palaeozoic component rapidly thickens to the south before shallowing toward the Bellevue area. This is consistent with the reflector dips north of Bellevue. It is possible that most members of the Lower Palaeozoic formations of western Tasmania are present – with the possible exception of Cambrian rocks. The gravity profile is not compatible with any significant volume of these units and the magnetic data do not appear to support their presence either. The central anomaly can be readily accommodated by the common Precambrian member and density consistent with the upper reflection set. Other reflections, approximately 1000, 1500 and 4500 m deeper, do not have any gravimetric or magnetic relevance and must represent structures which dip through the section.

Near Bronte the reflections can be explained by Lower Palaeozoic rocks (Ordovician to Devonian) overlying Precambrian dolomites and dolomitic sequences. There is no continuity demonstrable between the southern and central parts of the profile. A vertical offset is shown in the model but a steep dip to the south (or west) might yield a better solution. In the absence of any control information this amounts to overinterpretation. The time map (Figure 20_ shows the location of this major break. Magnetic data pick out at least two horizons which may contain ultramafics, one lies within the Precambrian complex at Bronte, but may be beneath it, and the other is within the Palaeozoic sequence at Great Lake.

The apparent antiform is thus in several parts, each constituted rather individually and not in a stratigraphic stack and, when seen in conjunction with line TD, the main form is found not to be closed near this profile.

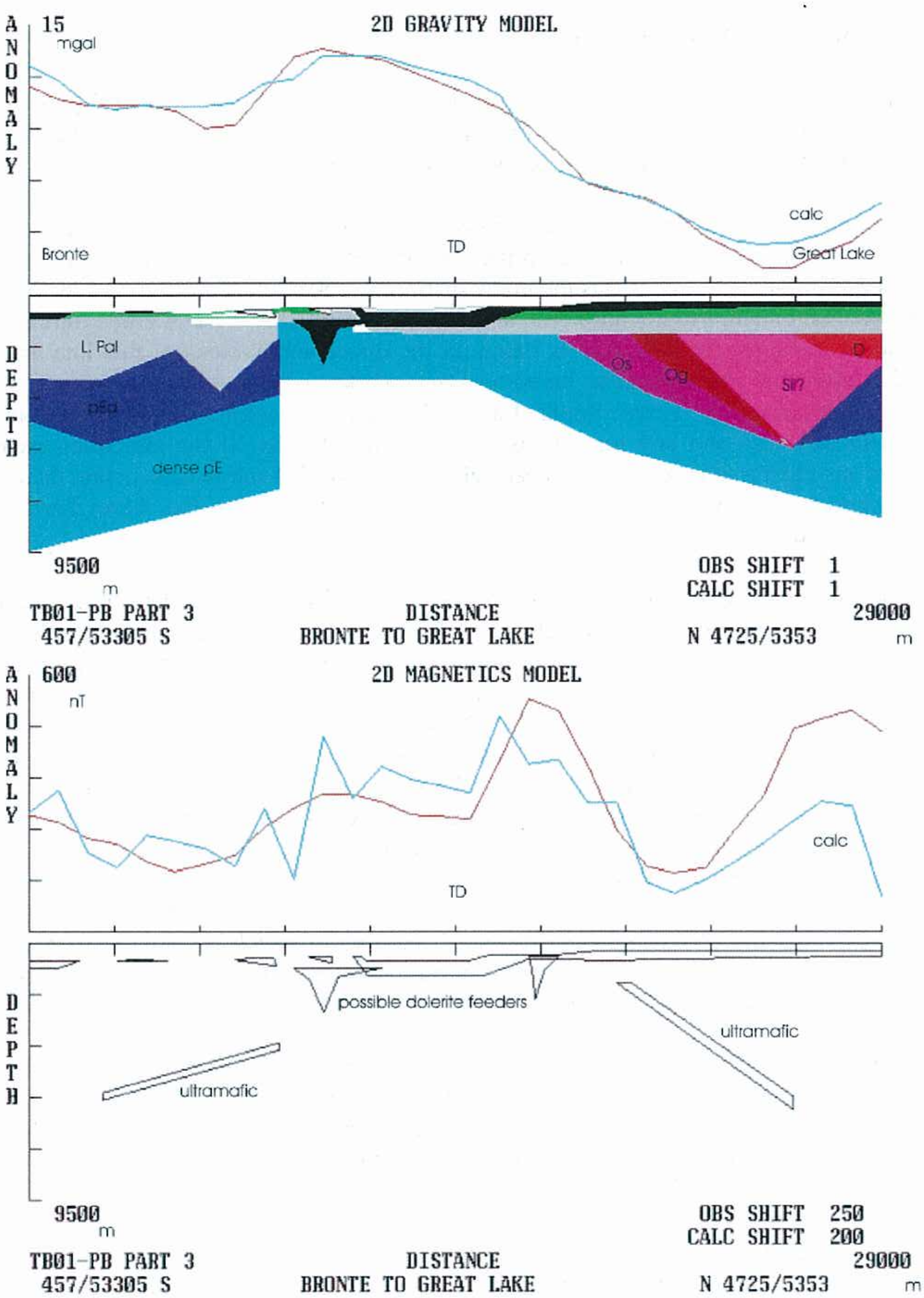

Figure 18. Interpretation of line TB01-PB, segment from Bronte to Great Lake.

Seismic LINE TB01-TD (2001).

Line TD provides a useful cross line for the structure at Bellevue (Line PB part 3) and shows that all reflectors can be linked. Parts of them can be traced laterally but dislocations are evident, just as noted in the above discussion.

The modelled line extends from Great Pine Tier (457/53477) to Bellevue Tier (466/53385) and the mid point is on the Marlborough Highway and a tie with Line PB, part 3. This short line confirms the many distinctive reflectors observed on Line PB and shows that one dips to the northeast, and the others dip to the west. A crude time map is offered in Figure 20. The map is based on the direct implications of this line and PB with inferences and limitations based on TB/TL (below). No part of the seismic surveys yet undertaken by Great South Land Minerals in central Tasmania provide a satisfactory grid and any time maps must be very sketchy. If the structures mapped have any closure it is somewhere near Lake Echo. Line TD simply shows that the major reflections dip west and that some sources reach up to the base Parmeener unconformity.

Major traverse PB has been interpreted without any Palaeozoic content in mid section in the location of the apparent antiform but there are some relatively shallow reflections on this line which indicate a more complex folded environment beneath the unconformity. Further, the gravity data – which are poor and must be confirmed – imply a positive crestal anomaly and which, if real, cannot be explained by a simple slab of denser Precambrian rocks. This situation is also constrained by the dips of major blocks or units and a structural crest in the region of Lake Echo at line end, not line centre. Lower density rocks must be present at the western end of the profile and the rollover of anomaly then becomes a natural result of the gross dips. The magnitude of the gravity anomaly also indicates that the thickness of Precambrian rocks inferred on line PB is an absolute minimum and, further, that denser units must be present. This suggests that line PB samples a portion of the area in which a dolomite sequence is present only as a thin cap on the more normal basement. The three dimensional nature of the structure and its contents may be demonstrated by comparison of the two profiles.
Magnetic data are distinctive and imply the presence of ultramafics near the contact between dolomite and the lower basement rocks. The extent of this material and the depth at which it could be emplaced has been examined and it has been found that the most likely location is shown in Figure 19. It is most unlikely that the ultramafics are present at the base of the denser Precambrian segment.

Figure 20 presents a crude summary of time events in the Bellevue region. Structures run up to the base Parmeener unconformity and the importance of review of possible sources, migration paths and seals becomes evident.

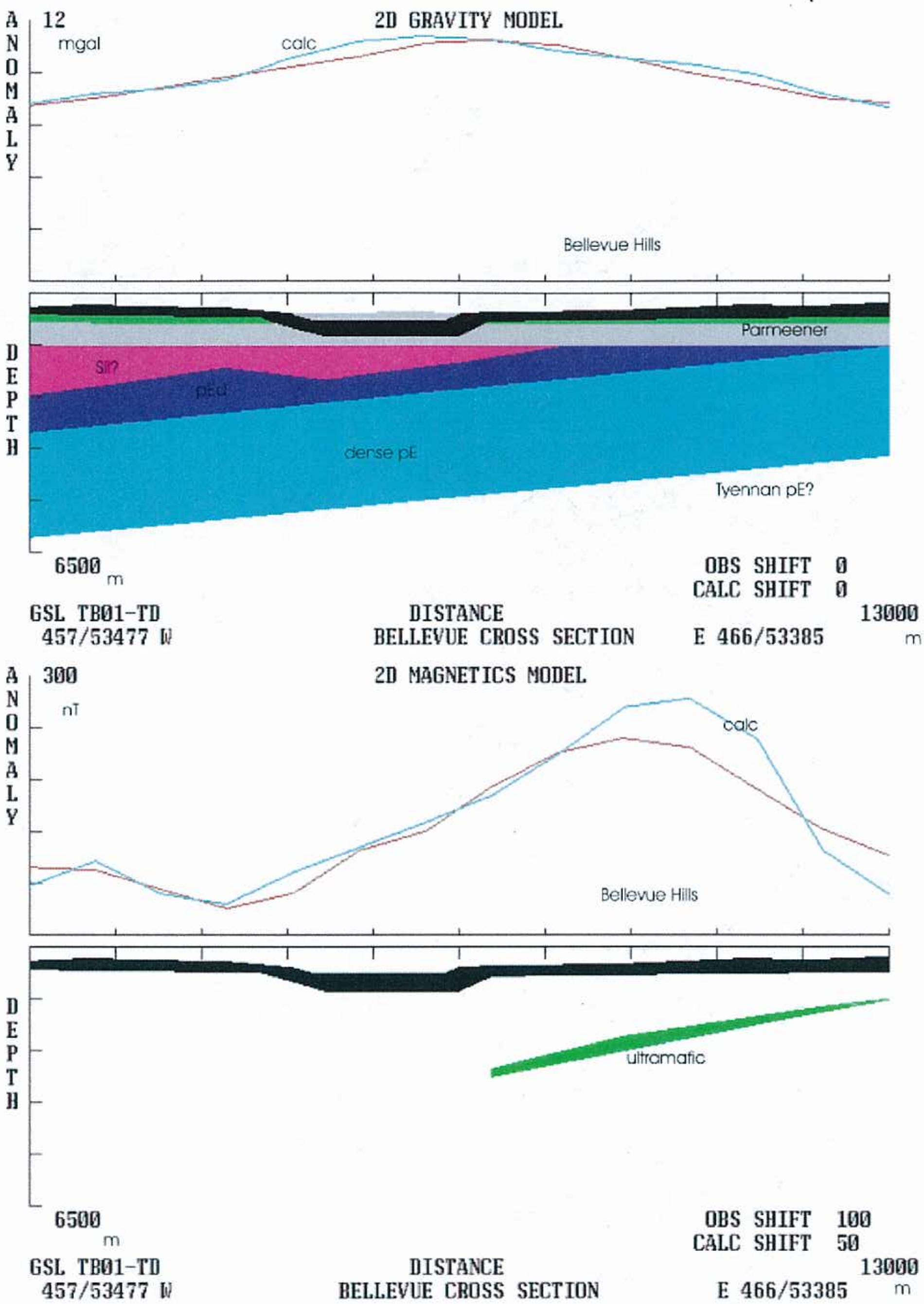

Figure 19: Gravity and magnetic models for seismic line TB01-TD, Bellevue.

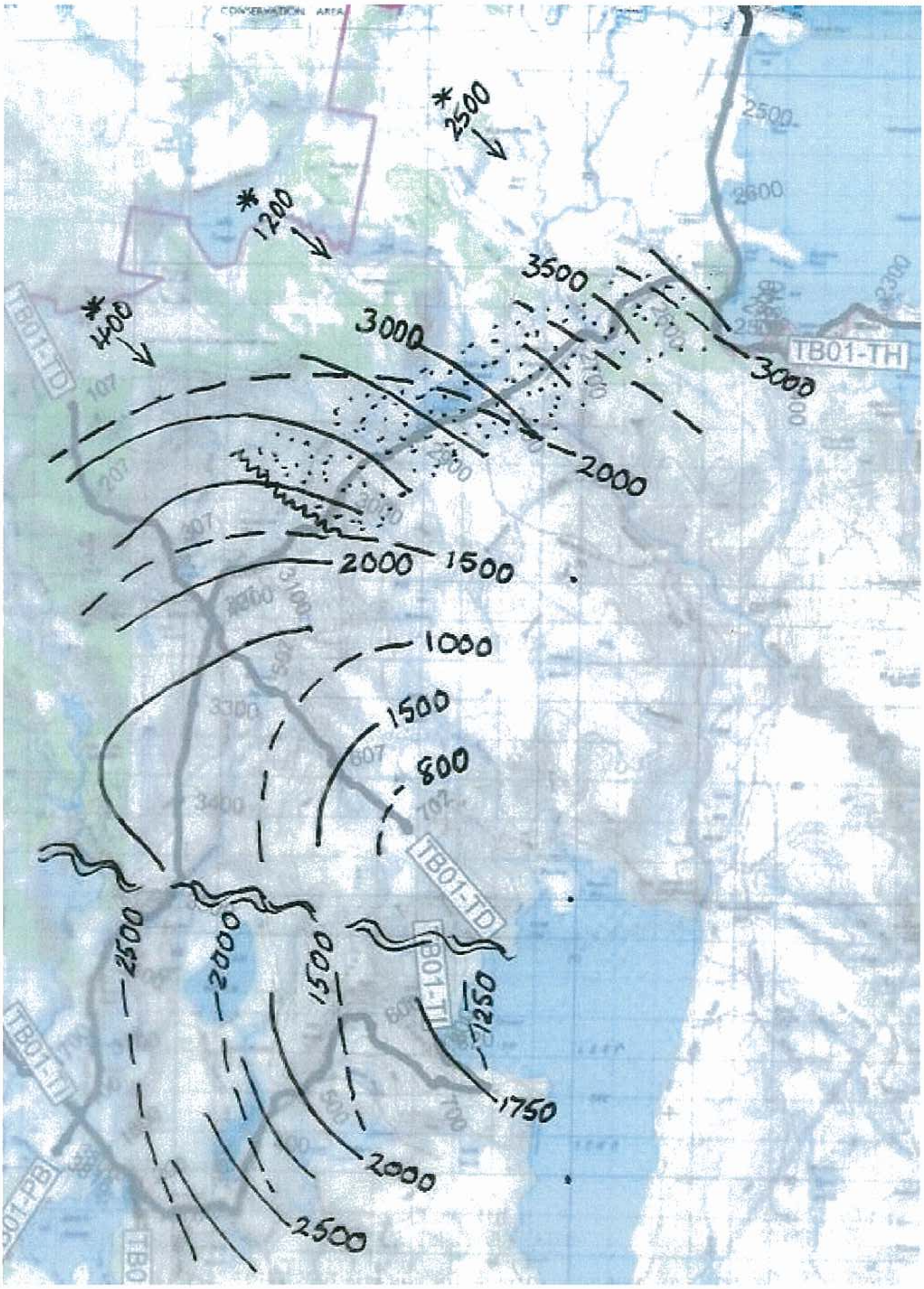

Figure 20: Three selected reflector events in the Bellevue region which suggest the gross structure. It is not clear whether these events have any stratigraphic significance or are merely thrust boundaries. The continuous lines represent the deepest marker, the broken lines are the intermediate marker, and the dotted area represents the shallow unit (arrowed times are for positions on the traverse but are offset for clarity).

Seismic LINE TB01-TB and LINE TL (2001).

The two lines TB and TL form a natural extension and extend from King William Saddle (426/5326) along the Lyell Highway through Derwent Bridge (436/5334) to Bronte junction (Marlborough Highway, 458/53323) and on to a point above Lake Echo (4678/53316). The segment from Bronte to Lake Echo is Line TL.

The problem of tying lines (PB and TB) is evident and the two solutions offered in this report can be considered as limiting possibilities. Orientation with respect to major structures is a further issue. Line PB offers a thick Palaeozoic sequence, dolomite and dense Precambrian beneath the Bronte road junction. This could be arranged in the model for line TB-TL (Figure 21) by inserting a wedge of lower density material above the Precambrian variations. However, the seismic character of Line TB is most distinctive and emphatic: there are several west-dipping structures beneath the region extending from Lake Echo toward Derwent Bridge. If these structures are accepted then a simple pattern such as shown in Figure 18 is not credible when seen in east-west alignment. It should be noted that both solutions could be correct and that Figure 18 presents the strike orientation, Figure 21 the dip orientation.
There is no doubt that the gravity field demands the presence of more than normal density Precambrian rocks and blocks of dolomite have been included in the model. These have been located consistently with seismic character.

Note the multiple reflector nature of seismic data at Bronte below the unconformity: this could be sheared Precambrian or the layered variations in the lithology of younger Silurian – Devonian rocks. The west-dipping character of the basement is demonstrated on line segment TL east of Bronte (see also Figure 20).

Very different conditions apply at the western end of the traverse, beneath Mt King William. In this zone there are arcuate reflections which are synformal and within this package there are east-dipping elements. Few of these features have any continuity and the entire suite is bounded by a large east-dipping structure or unit. The gravity model is defined by these features and scaled by them. When this is done it may be inferred that nearly all parts of the west Tasmanian sequence are present in a large fold with offsets and onlaps.
Magnetic data, although at the edge of reliable coverage, offer some important constraints and generally confirm the gravity picture. A slab of slightly magnetic material is present in the gross fold and can be presumed to be Cambrian volcanics. An alternate view would be a segment of metamorphosed Precambrian but this would not be easily fitted into the density profile required to balance the gravity field. Ultramafics are also present, partly as a slice between Precambrian blocks and partly within the main fold – at the base of the inferred volcanics. This is a pattern commonly observed in western Tasmania.
Although the location of anomalies is a little vague, and the disposition of sources producing them necessarily uncertain as a result, each west-dipping boundary to the dolomitic blocks would appear to be picked out by slices of ultramafics. This conclusion supports the general view of the interpretation that the modelled aspects of the structure, as seen near Bronte, are determined by line orientation across a complex dipping environment full of detachments.

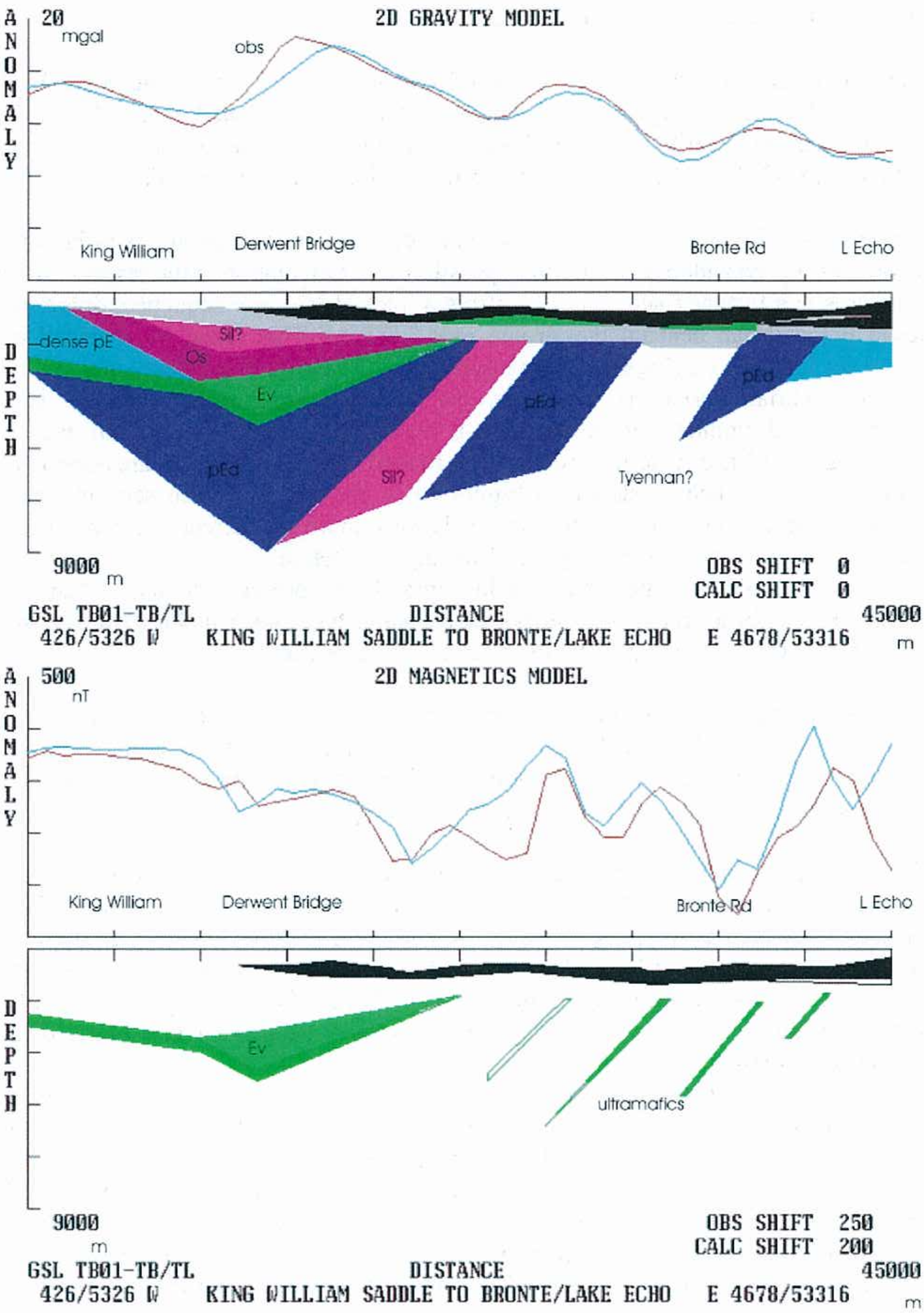

Figure 21: An interpretation of seismic lines TB and TL, Mt King William to Lake Echo.

DISCUSSION

The analysis reported above is almost wholly consistent with previous work, with some significant variations, in terms of the general structural content, gross lithology of basement, and structural style of the rocks deep beneath central Tasmania.

The use of the limited seismic coverage available has removed many interpretation options and clearly demonstrated the presence of two families of thrusts: east and west dipping.

Comparison of many modelled lines, in the few places that they overlap or intersect, will show some minor deviations or alternatives. As noted earlier this may be due to orientation and observation issues, but is generally due to incorporation of slightly different concepts where the seismic data allows or is silent. Thus, Line PB (central part) and Line ST, at Steppes (Figures 15 and 16) for example, present similar materials or sequences but a different balance of them. Much depends on the data control in each segment, the change in line orientation, and the feasible combinations of units and physical properties.

In the context of central Tasmania the cover of post Carboniferous rocks (Parmeener Supergroup and dolerite) is almost irrelevant. It is a relatively thin veneer with regional dip and distortion. Any structures within it have origins and associations in the underlying complex. This means that the Hunterston structure, as seen in the Permian rocks, is related to rejuvenation of the underlying thrusts, some of which involve Cambrian and Devonian activation and creation. Several Jurassic dolerite structures are also related to these sites and changes in sheet form seem linked. Many feeders, most of which are not accurately located by gravity or magnetic data as yet, may also be associated.

There are enough magnetic data to demonstrate that a number of structures include, or are defined by, material with ultramafic properties. This material is Cambrian in age but has been relocated structurally. Many of these structures are seismically defined due to the different properties of the ultramafics, and the sheared and fractured nature of the zones in which they now occur. The broad spread of reflections in some regions indicates highly sheared, structurally layered rocks. Few of these zones are extensive.

Precambrian rocks are, in general, at non commercial or non productive depths although a number of blocks crest to, and are overlain by, the Parmeener cover – as at Hunterston and Bellevue. Various dipping blocks have been identified which are thrust-bounded.
On the presumption that rocks younger than Cambrian are of most interest to the exploration program Figure 22 has been prepared to suggest their location and any inferred structuring. This diagram is focussed on the Central Plateau region since this is the current location of most of the seismic network. Other seismic lines straggle to the west or south and lead to Palaeozoic rocks but, until there are tie and cross lines – and more potential field data – it is not possible to infer much about the possible structures (see Recommendations).

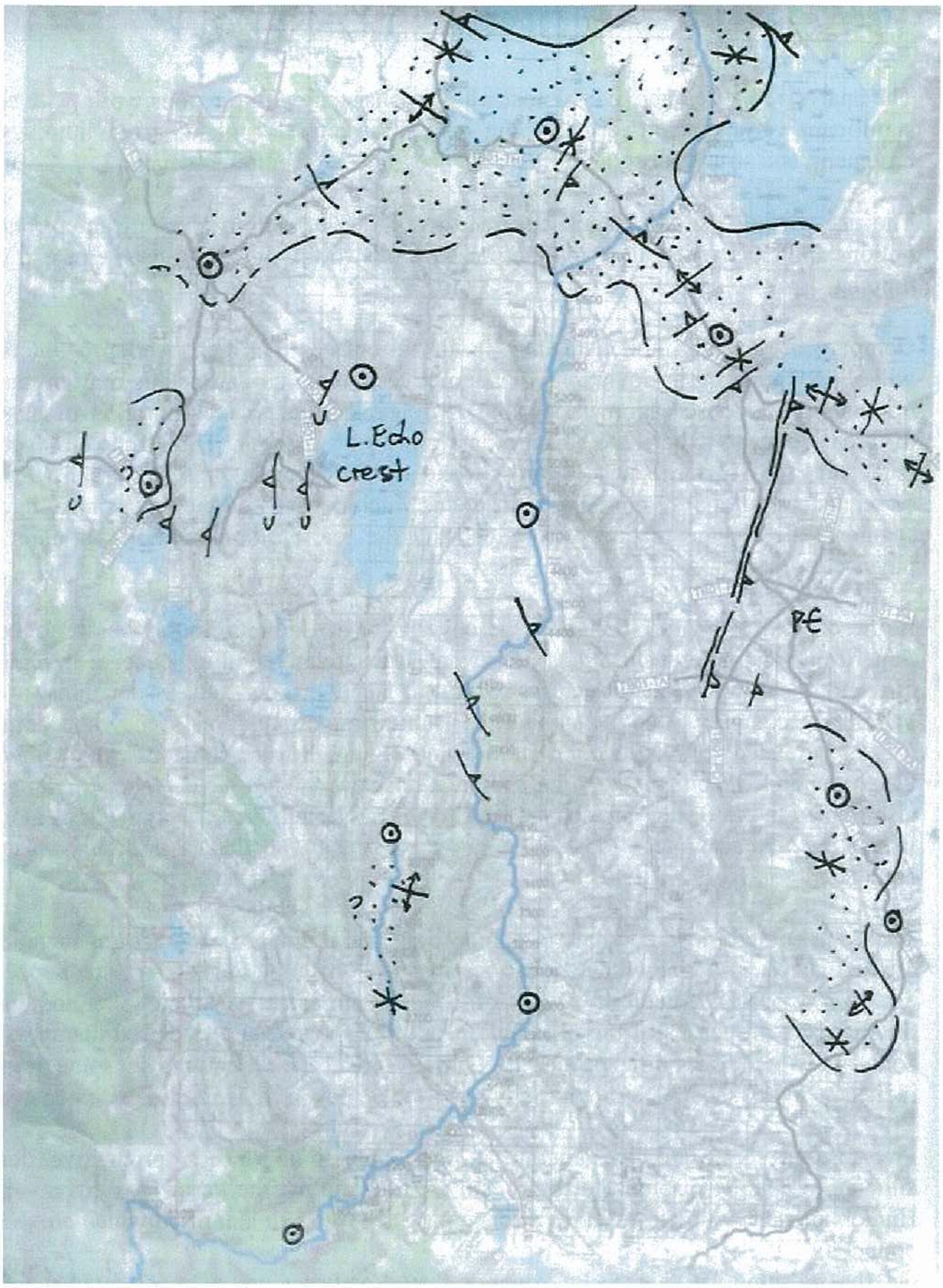

Figure 22: Inferred location of mid Palaeozoic suites.
The diagram also shows the location of major thrusts but few of these can be oriented nor connected with the present information. Dotted areas indicate inferred presence of Ordovician-Devonian rocks directly beneath the base Parmeener unconformity. Fold symbols are also marked. Circle symbols locate nominal positions of recommended control bores on the basis of present work. Basemap shows location of existing seismic traverses as heavy, coloured lines.

Figure 22 also does not consider the situation in the south-eastern part of the licence area where it is thought that the Mathinna Beds sequence predominates. This region is not adequately surveyed by any means as yet and no conclusions can be drawn. There is clear evidence of a large fold and possibly monocline at the foot of the Great Western Tiers. This structure probably involves Mathinna Beds and is also broken by a series of faults and thrusts in possible flower and rift margin structures. Such a zone may not be prospective in any event due to clear leakage possibilities and broken seals.

There are a number of other locations where ambiguity requires either more data, more analysis or review. For example:
What happens at the edge of the inferred Palaeozoic sequence which dips west from the unconformity beneath the segment Bronte to Derwent Bridge? Could traps exist in this region?
More control is needed near Bellevue. Where exactly does the shallow cover inferred to be mid Palaeozoic rocks become truncated by the unconformity? Could traps exist? Gezer-1 will answer some of these questions.
The situation near the highway junction at Bronte must be resolved. Are Palaeozoic rocks present, and what are they?
More detail is needed on the underlying section north of Breona and south of Miena. Are Palaeozoic rocks present, and what are they? Similar comments apply to the sequence between Steppes and Woods Lake.
Is there a structural closure north of Hunterston? There does not appear to be one in the post unconformity rocks but the identification or demonstration of mid Palaeozoic rocks to the north may prove important.
The situation involving possible mid Palaeozoic rocks in the region north of Ouse must be resolved: does the succession extend east of the Derwent axis?

It must be stressed that this interpretation is essentially uncontrolled and based on insufficient data for acceptable reliability risk. It must be regarded as preliminary and indicative only.
The seismic coverage, with its awkward line orientation and terrain changes, generally lacks ties and does not allow proper definition or mapping of any unit or structure over worthwhile distances (except for some parts of the Permian rocks and some dolerite sheets). The gravity coverage ranges from excellent to terrible and much weight has been placed on too few observations. The magnetic coverage is uniform but coarse and, ironically, turns out to be the best regional data set, as a data set, at the time of writing. It is simply a pity that the wide line spacing leads to limited resolution of features and locations.

This interpretation amounts to an over-interpretation in many regions and the Recommendations (below) are designed to solve this problem and advance the exploration effort.

This study includes no evaluation of the seismic or other data coverage northeast of the Great Western Tiers. A comprehensive view of that region, a view consonant with new data, was provided by Leaman (1991, 1992) and Leaman & Webster (2002). It may be commented, however, that the seismic net for that region is the minimum standard for useful judgments and the new program for the southeast is compatible.

OTHER OBSERVATIONS

The above discussion and interpretation, with its emphasis on old rocks and complex structural relationships, would seem to offer little for a petroleum exploration program. The sequences, and lithologies, inferred are of high velocity and structured. It is a thrust terrane. All formations in these circumstances are likely to be of low porosity but may be locally fractured. In such fractured zones they may form adequate reservoirs for gas or fluid and the same zones would also be critical for any fluid migration, or escape.

It is often assumed by "soft rock" explorers that hard rock terranes carry little potential for petroleum – but this is clearly not the case in some Asian provinces. The same principles, involving source, migration and storage apply: is it possible?

Various theories for potential source rocks have been presented for the Tasmania Basin – a term which might itself be of little value. This, and previous, regional interpretation indicates that the post Carboniferous rocks of the "basin" are but a veneer with very modest variation in thickness and which have been largely removed as a cover. Migration is clearly possible per the net of thrusts, faults and fractured zones and, perhaps, near unconformities.

In such situations the matter of seals becomes paramount since many fracture systems have been rejuvenated and extend to surface. The potential for leakage is high and this pattern probably accounts for the Lonnavale observations of escaping oil through dolerite. Set against this negative view is the fact that nearly all media encountered in central Tasmania, and implied in the above interpretation, including Permian rocks at depths greater than 100-200 m, have velocities in excess of 5000 m/s; most in excess of 6000 m/s. It is known, for example for Permian rocks and dolerite, that this translates into a tightly sealed rock mass in which joints are filled and effectively impermeable. There is an observed velocity profile in such rocks as surface is approached representing first an opening of joints (due to unloading) and then due to increasing effect of weathering. For the dolerite the critical change occurs at depths of 40-80 m below surface. Below such depths the rock is a seal. Thus for dolerite, within section as a complete sheet, the intrusion itself represents a seal.

It might be expected that many other, older high velocity lithologies would act in a similar manner. In these terms, Lower Permian rocks deeply buried (depths > 200-500 m) would also act as seals – regardless of lithology. No such assumptions should be made for Triassic or younger sedimentary materials.

These comments mean that many units, viewed stratigraphically or as structural members, could act as seals. The issue for exploration is, could reservoir settings be developed and recognised in such situations, or with less than excellent data. In normal situations dipping reservoirs, whether structural or stratigraphic, may well display anomalous reflections: direct hydrocarbon indicators (DHIs) in which a strong horizontal reflection can be contrasted against its dipping setting. Using the currently available data, with all its limitations, there are few unambiguous stratigraphic