CONTENTS

TABLE OF FIGURES

SUMMARY

A comprehensive review and interpretation has been completed of the central plateau region of Tasmania; an area of exploration interest to Great South Land Minerals Limited (GSL) which holds a petroleum exploration licence. This work was undertaken in order to assess the nature of structures and stratigraphy, whether any prospects were already identifiable and which areas required further data – and the nature of that data.

Previous work had suggested that the post Carboniferous cover across most of the region was relatively thin; generally less than 1000 m. Underlying structures and sequences are unknown but extrapolations from surrounding regions suggest a range of Precambrian and Palaeozoic sequences. These were thought to be arranged in folds and thrust stacks with many wedged and unconformable relationships. Well control of these deep units is restricted to one well which encountered dolomitic Precambrian rocks. All other knowledge is inference from preliminary gravity and magnetic interpretations.

Acquisition of some high quality seismic data has led to a review of such preliminary studies and the present work is the most detailed study yet done of the region. It has exposed the considerable weaknesses in the data available and of the problems of acquiring sound data in the first instance. These problems involve the terrain (often rough and of high relief), non straight traverses, and irregular sheets of Jurassic dolerite which intrude the cover rocks and which are often exposed. Each of these factors work to degrade the quality and value of seismic data. The present traverse coverage also leaves much to be desired and recommendations have been offered on this point.

The fragmentary nature of reflections and lack of continuity, coupled with negligible factual control of lithology, has required the integration of potential field data in order to assess structures and probable lithologies from inferred property and geometry combinations. It should be noted that all previous work amounted to free potential field interpretations since no significant seismic data coverage existed until the GSL surveys of 2001 and 2006, nor did well Hunterston-1 which, at least, confirmed an earlier prediction of basement type at the site. Assessment of the disjointed and block nature of structurally framed elements requires use of many methods.

Unfortunately this type of analysis places demands on the data which the gravity coverage (Tasmanian state data base) could not meet uniformly across the region. The magnetic coverage, acquired by Conga Oil, was of useful quality but restricted in value due to its line spacing. Further, the geological data base is woefully inadequate across nearly all of the region and further analysis, analysis using improved data and able to handle the issues posed within the cover sequence, will need some improvements in this knowledge. Improved gravity and magnetic coverage, so critical to full integration of blind seismic data, or poorly controlled seismic data, has been recommended: as has some ground inspection of critical exposures and areas.

The analysis essentially confirms the structural style predicted by earlier, less detailed studies completed in the absence of seismic data. Most major reflections appear to involve Cambrian ultramafics and are thrusts. Both east-dipping and west-dipping thrusts have been identified and many blocks are fully enclosed by such structures and such materials.

Folded structures may be traced beneath the cover from exposed elements in the west near the Florentine River valley and Mt King William, and from the north at Golden Valley. In some cases most major Palaeozoic rock sequences, as exposed in western Tasmania, may be inferred. There are many cases where key elements are missing and the most common omission is Cambrian in age (volcano-sedimentary sequences and volcanics). Not all units can be identified with confidence but the presence of the lower density, non magnetic Silurian and Devonian members have been deduced in various areas, mainly south of Great Lake. These rocks may offer reservoir potential and older source rocks may underlie them.

The only region which, given present data and analysis, might contain a nest of potentially closed structures is near Lake Echo, east of Bellevue. These structures are tiered and not concentric but are not yet defined to the east. Much effort should be focussed on this region.
Many other structures which present apparent crests would seem, at this stage, to be open in at least one direction. This is especially true of any structures involving the post Carboniferous (Parmeener Supergroup) cover, plus dolerite. The cover, indeed the entire region and the basal unconformity involved, is ramped with long wavelength regional dips. Apparent domes are not closed domes; they open, usually to the north. This observation will have implications for migration and reservoir assessment involving these rocks.

A number of ambiguities and conflicts have arisen which cannot be resolved with present data, and without further well control. Recommendations have been offered of drill sites which would resolve some of these uncertainties, constrain any future analysis and improve general understanding of the region.
The preparation of such recommendations, coupled with suggestions about structures, structural style and some sequence compositions, can be considered both the aim and result of this integrated review.

It must be clearly understood, however, that the interpretation has stretched the data sets to their power of resolution and, in some cases – especially gravity in western areas, exceeded this. Some aspects of some models offered are over-interpretations of gravity data, but within the resolving power of the seismic and magnetic data available.

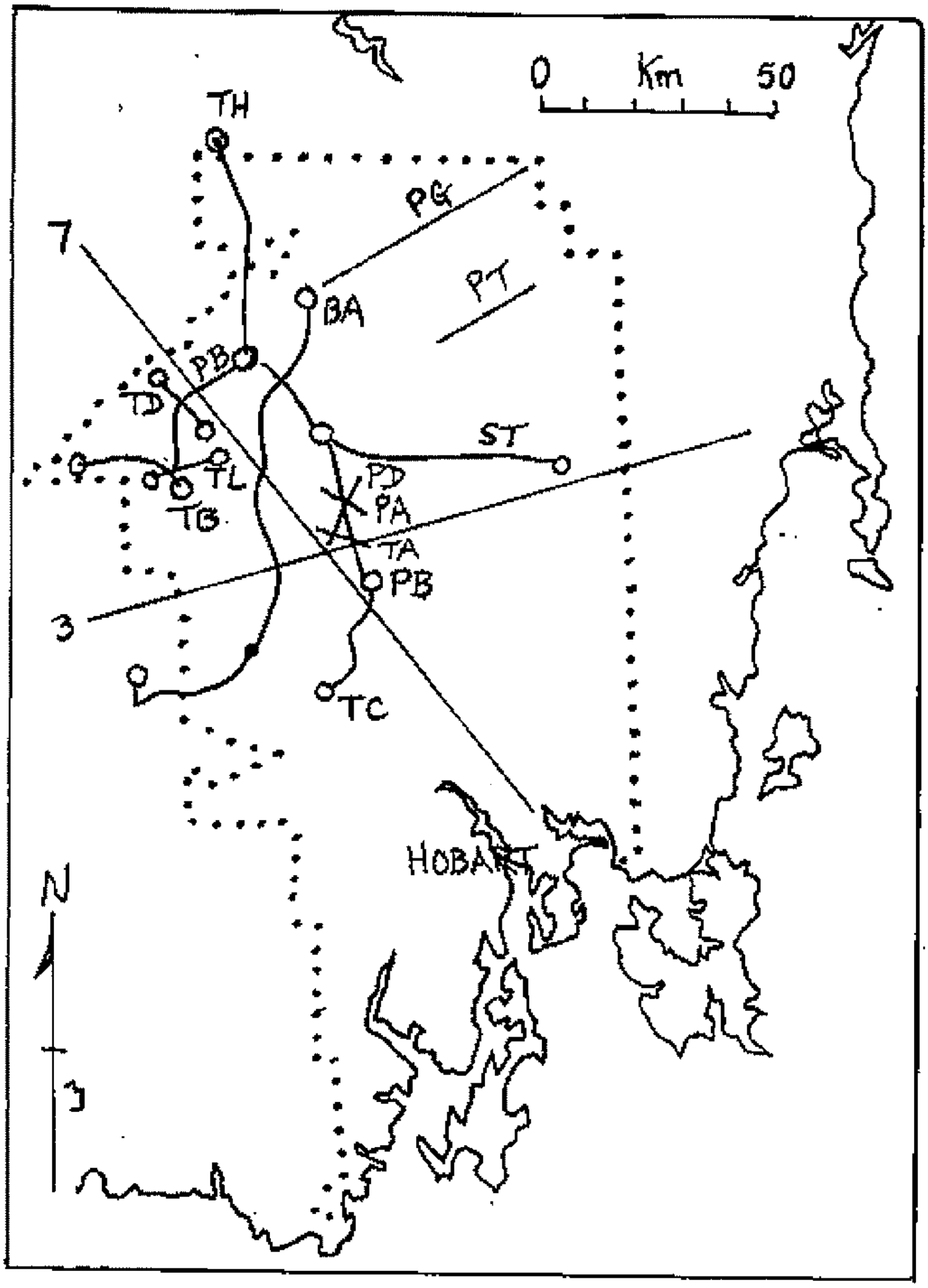

Figure 1: Location of licensed area and seismic lines, central Tasmania. (Additional lines are available in the northeast part of the licence area but these map post Parmeener structures and are not generally relevant to the present study. Lines PG and PT have been included from this set for reference purposes only)

INTRODUCTION

The integrated interpretation presented in this report was commissioned by Great South Land Minerals Limited (GSL) for several reasons. It is important that those reasons be stated, along with some comments about the inevitable limitations contained in the analysis. This interpretation is, at least, a current update of past research and a comprehensive improvement will not be attained until many elements of the data sets are themselves improved, and there is significant coverage of deep well control in the complex – and largely unknown – pre-Permian geology of central Tasmania.

The geological setting

The licence area, and adjacent region, is largely blanketed by a nearly flat-lying cover of Permian and Triassic rocks intruded by sheets of Jurassic dolerite (or dolerites) of varied thickness. This cover largely blinds the explorer seeking stratigraphic relationships (sequence thicknesses, contents, onlaps, unconformities, variations) or structural features (folds, ramps, faults and thrusts). These two classes of relationship form the heart of petroleum exploration. They are not evident in central Tasmania although it is clear that rock units, as exposed laterally, do possess considerable variations which may well offer potential. Further, some lower Palaeozoic rocks can generate, and have generated, hydrocarbons, as may some Lower Permian formations. Previous documents (such as GSL 2002) prepared for Great South Land Minerals Ltd have demonstrated these facts, essentially supported by Bacon *et al* (2000).

A few studies of the pre-Parmeener (essentially pre-Permian) sequences and structures beneath central Tasmania have been completed. These are by Leaman (1987, published as Leaman, 1990) which considers southern Tasmania, Leaman (1991a, b) which reported a more preliminary study of northern and central Tasmania, a private revision used as a framework for Leaman (1996b), and elements of TASGO project (2001) and selected sections of Leaman & Webster (2002). The original 1990 study of central Tasmania was begun by an earlier parent of the present company but work was halted due to funding and data constraints. The implications were summarized in Leaman (1991) and incorporated in Leaman (1992) and Leaman *et al* (1994).

These relatively limited studies, undertaken in the absence of significant seismic coverage, indicated a complex, repeated thrust regime in which the thrust packages generally dip eastward but, in the western part of Tasmania, and the western part of central Tasmania, often dip westward. Both regimes are known to exist in western Tasmania. This pattern could be expected across the entirety of basement Tasmania but it appears that east dipping thrusts become dominant in eastern Tasmania.

The first seismic problem

There is little about the geological setting which, in normal circumstances could not be clarified, perhaps resolved, using the seismic method. The crucial factor is the Jurassic dolerite, its variable presentation on the land surface – in terms of soil and weathering cover, and its variable and generally very high velocity at shallow depths.

Any failure to appreciate these variables has devalued and degraded seismic data. Early work (Leaman, 1978b, Leaman & Richardson, 1980, Richardson & Leaman, 1981) showed that good reflection records could be obtained where high dynamic ranges were sustained using a wide frequency range (15 to 120 Hz at least). In such conditions the depth of fracture closure (and its velocity step) was recognisable, as was the base of the intrusion and some features beneath it. Overstacking was not always found to be beneficial and best results were obtained in this early work where dolerite occurred at some depth (> 100-200 m), and preferably beneath water or low velocity sedimentary materials (< 2000 m/s). Most problems were encountered when dolerite was at surface and this was exemplified by test profiles at various locations (Leaman, 1978b; 1996a; Leaman & Richardson, 1980). Indeed, Leaman (1978a) suggested varied firing and stacking patterns might be needed for optimal results: a potentially costly option. This research was summarised in Leaman (2002).

The problem for central Tasmania is apparent: dolerite is on surface for much of the region.

Why is dolerite a problem?

Dolerite is a high velocity medium but this need not be cause for difficulty. Many other formations may possess similar velocities and, provided they are part of the stratigraphic cake, will be mapped and defined.
Dolerite, however, is rarely "part" of the stratigraphic cake. The intrusions tend to be irregular, transgressive, multiple, near surface, and extremely variable physically. All such characteristics disturb the assumptions of the reflection method, data stacking, processing and migration.
The issues related to dolerite have been summarized in Leaman (2002). See Figure 2.

The second seismic problem

Other seismic problems are related to line location and terrain. It is simply unrealistic and expensive to traverse straight, cut lines across the body of the Tasmanian countryside, and few valleys offer any line length. Consequently, traverses must be irregular in three dimensions: a factor which is not critical for deeper reflections in general since these can be inferred, located and shifted in processing provided the line excursions are not too great. Unfortunately, the dolerite-near-surface problems (geometry and physical variability) compound the line geometry issues and degrade reflection quality – typically for two way times of less than 0.5 to 0.8 seconds. This time range tends to contain all the Parmeener (post Carboniferous unconformity) information – including the dolerite.
All these elements are evident in GSL's seismic data (2001 and 2006 surveys). Fragments are shown in Figure 3. The presence of Permian and Triassic rocks at surface enables reasonably clear definition of a contained dolerite sheet. But, where dolerite is at surface, it is often difficult to recognise the intrusion base and other sequence character – including the nominal base Permian unconformity, is obscured and diffuse. There are exceptions where uniformity of dolerite character at surface, and of terrain and line orientation with respect to structures, permits adquate resolution (e.g. Figure 3A, B),

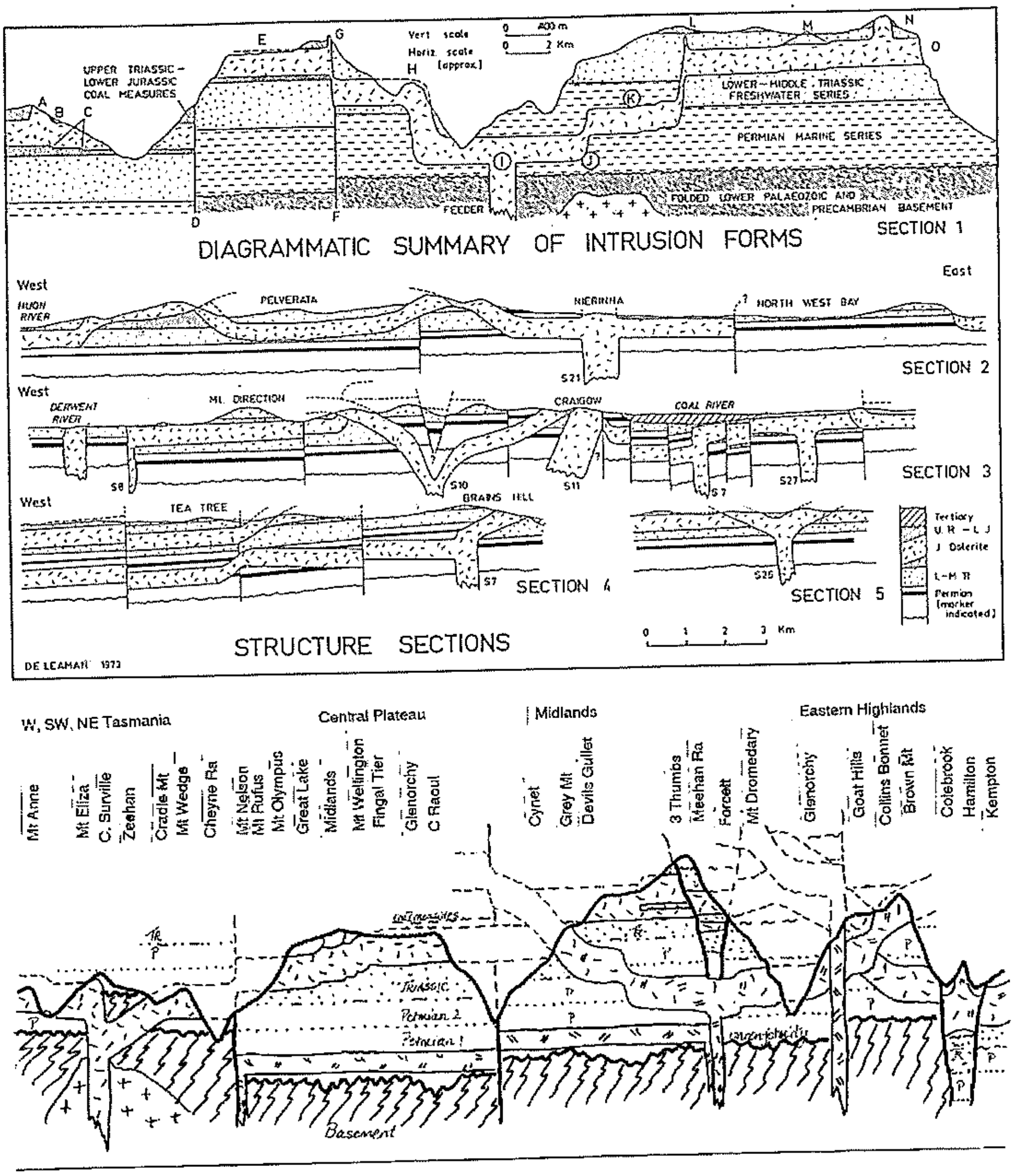

Figure 2: Examples of style of dolerite intrusion.

Upper diagram from Leaman (1975) and lower diagram from Leaman (2002). Each serves to illustrate the enormous range of intrusion relationships. It is also now known that many (if not most or all) intrusions have been multiply injected; a factor which can complicate interpretation or field decisions about apparently small intrusions or exposures.

North Great Lake), but these are quite limited in extent. Their importance cannot be over-emphasized since any clarification of section or spatial information provides vital control. Spot control, however, cannot replace continuous data or profiles. Careful specification and observation of the survey is essential.

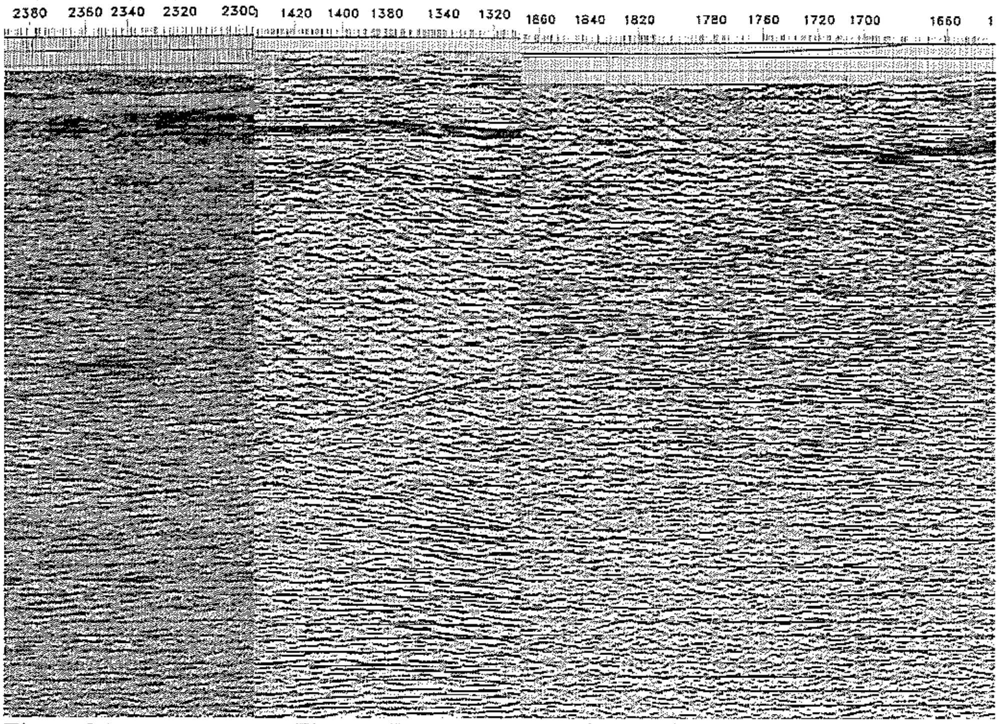

Figure 3A Figure 3B Figure 3C

Diagrams to illustrate the variability of responses and effect of Jurassic dolerite.

Line TB02-AA2 Line TB01-TH Line TB01-TH
North of Strickland High plateau, Lake Hwy Beside Great Lake, Lake Hwy
Triassic rocks at surface Dolerite exposed at surface. Note the marked change of character near SP 1720 implying a major change in dolerite geometry or properties, or both. Much detail, in the upper part of the section has been lost or much obscured.
Dolerite is indicated by a "white" zone. The base of the dolerite is marked by a moderate reflection. at about 100 ms.
Good result Good result Poor result

The third seismic problem

Reflection character from the Parmeener (and dolerite) part of the seismic records can be reasonably correlated with known units: at least as gross packages. Figure 3B is an example of this. Many members of the Permian part of the succession can be identified in adjacent parts of this traverse at the head of the Great Western Tiers where the stratigraphy is well known. Blackburn (2004) also made this point. In these terms, and in comparison, the dolerite may be seen as bland and uniform – unless transgressive, but Triassic and Permian rocks may not be unambiguously separable.

Not enough is known of responses from Triassic rocks and definitive interpretations of sequence type (sandstone or mudstone dominant for example) is not possible. In many cases it is not yet possible to discriminate Upper Permian siltstone sequences and Lower Triassic sandstone sequences.

The real problem, of particular significance to the exploration by Great South Land Minerals, relates to identification of unit packages of Lower Palaeozoic and Precambrian rocks. Some of these may be source rocks, others reservoir rocks.

Inspection of RMS and interval velocity panels reveals that velocities involving dolerite, deeper Permian sequence, and all underlying rocks are not ready distinguished: all present velocities in excess of 5000 m/s, typically 5500-6500 m/s. Yet reflections, often high amplitude reflections, are observed from beneath the base Parmeener unconformity. Many of these features must be structural, fault or thrust elements, but some may be stratigraphic. The problem is how to link such features in geological sections and to infer lithologies, sequences and ages.

Control information is available only from the Deloraine-Golden Valley-Poatina area in the north, and from two traverses west of the central region (to Florentine Valley – line BA, and to Mt Arrowsmith – line TB). The highly patchy nature of the folded, faulted, overthrust regimes in northern Tasmania, as demonstrated in exposure and replicated potential field geophysical studies, rarely provide much assistance to interpretations of such profiles since the style of structural disruption is such that blocks are either too small (laterally), or dip too steeply. Studies beyond the confines of central Tasmania suggest the regional style which should be anticipated. Further, conditions to the west, from Mt Arrowsmith and the Florentine valley, imply major thrusting but do not permit clear tracing of units into the heart of the traverses – central Tasmania.

The role of other data sets

Available geological compilations are not relevant to resolution of the critical problem: what happens beneath central Tasmania. But, as noted below, the quality of the available mapping is not sufficient to resolve secondary questions or assist other data sets (gravity and magnetics) with specific site reviews.

Extant gravity and magnetic data can contribute to an understanding of the deep structure and lithology and this has been demonstrated by interpretations offered in the last two decades (e.g., Leaman, 1990, 1991). These interpretations have depended on extrapolation of known types of relationships to the regions examined, and then some unification of the implications of the methods or data sets. Some objective tests are available to establish whether a solution is viable and credible – not necessarily correct in the absence of well control. These tests, defined in Leaman (1994), allow recognition of spurious solutions which might fit the observed data but which are not viable in the particular setting. As such, much ambiguity can be removed. These techniques for testing solution viability evolved during the period of the earliest interpretations and, indeed, that work led to the tests and an appraisal of them. Only interpretations after 1991-1994 should be assumed to have been filtered by the testing criteria and the improved methodology of Leaman (1995, 1997b).

The early interpretations were provided in the absence of usable or extensive seismic data, or useful well control – or useful distribution of such control. Sites in the upper midlands, and at Glenorchy, provided the only control on basement lithology. This problem remains.

It has also been shown that seismic data interpretation of complex terrains can be quite misleading in the absence of interpretations of other data sets. An example of this was provided by Leaman & Webster (2002) for a traverse across the Dolcoath Granite in northwest Tasmania in which the seismic interpretation did not define the intrusion. Gravity data, however, were quite definitive. Consequently, the opportunity to match seismic sections with indications of high angle or deep boundaries and gravity and magnetic data means that some assessment of the rocks and sequences involved in the reflected features might be possible.

The present preliminary interpretation is based on this premise.

Problems with gravity and magnetic data

The integration of data sets is an advised approach but the results depend on the quality of data available, and the methods used for interpretation and integration.

In the case of central Tasmania, there has been no significant change in the gravity data base since the work of Leaman (1991). The manner of presentation, and direct usefulness, of the data available has been transformed by the conversion from raw Bouguer anomalies to crustal-isostatically corrected residual Bouguer anomalies. This was made possible by the series of gravity interpretations undertaken after the observations collected for the Mount Read Volcanics Project of the mid 1980s and the regional scale evaluations which followed. The reported interpretations relevant to the present study were undertaken in this environment of changing understanding and processing. The methodology was reported by Leaman & Richardson (1989b) and has been refined subsequently (Roach *et al*, 1993). The conversion to residual data, whilst not improving the detail of the coverage, does allow focus on the upper 5-10 km of the crust with no need to consider deeper crustal, mantle or oceanic effects.

These improvements do not replace the need for good, reliable data coverage – and herein lies the weakness in the present data set. Some regions, especially south and east of 480 000 mE, 5300 000 mN, are reasonably served. Others are not. The Arrowsmith, Great Lake, Bronte, Interlaken regions are poorly covered, and the region west of Tarraleah and National Park is very poorly covered.
All extant stations have been terrain corrected but reliability often depends on accuracy of elevation determinations – which have, until recently, been mainly barometric. Likely errors in the Bouguer anomalies are of the order of 0.5 to 1 mgal. Gravity data thus have varied application, depending on region and reliability, but where coverage is fair then this data set is able to guide an interpretation of pre-Parmeener rocks.

Magnetic data are both more detailed and also more problematic.
This paradox reflects the nature of coverage and the variation in rigour of survey and specification. Three relevant data sets are in existence.

The first is a state coverage with modest traverse spacing acquired by AGSO in 1985. It has an E-W line orientation but was acquired with an unknown, varied terrain clearance (150-1000m) which renders quantitative interpretation or reprocessing impossible.
The second survey, flown at high level (1600 m) but fixed height, was acquired by Conga Oil Pty Ltd (a predecessor of Great South Land Minerals Limited) in 1989. The E-W lines are spaced 5000 m apart and this coarseness limits detailed value. It remains, however, the only consistent and fully specified, recoverable regional scale survey of central Tasmania.
The third survey, much more limited in coverage but more detailed, was undertaken by Mineral Resources Tasmania of the Oatlands area. The E-W lines have a separation of the order of 200 m and were flown with nominal terrain clearance of 100 m. This fine survey allows resolution of local and near surface features but lacks the coverage to allow full integration with the Conga survey or the present seismic coverage.

The Oatlands survey allows comprehensive assessment of Parmeener features and the dolerite intrusions. The AGSO data provide an indication of magnetic texture and trends of features but only the coarsely spaced Conga survey allows any quantitative regional interpretation, due to its fixed reference base. Data acquisition at high level, using coarsely spaced lines, does limit the interpretation options but a first order structural evaluation is feasible using this data, and it has been used to test various seismic and gravity implications and was used extensively by the 1990-1 interpretations to generate a view of basement structures and contents.

A relevant extract of the summary of the 1991 interpretation is shown in Figure 4. A sample of the updated revision of this interpretation provided for inclusion in the Regional Forest Agreement documents is shown in Figure 5 (from Leaman, 1996 prior to final drafting).

A more detailed, consistent magnetic data set must be acquired before any truly reliable evaluation is possible. The data interpolations, between lines, necessarily degrades certainty of location of features, or the gradients and magnitudes associated with any anomaly.
The present situation is parlous and quite unsatisfactory and probably would not be tolerated in any other Australian state. The Federal agency survey (1985), and its failure, is the fundamental reason for this condition and reflects practices which treat Tasmania as a guinea pig. State-funded surveys in west, northwest and northeast Tasmania, as well as near Oatland, are of an order better in quality but state funding has not provided an adequate coverage either of geological or geophysical information in central Tasmania as a whole.

Issues for interpretation

The interpretation provided below relates limited geological surface control to seismic response, and to both gravity and magnetic anomaly patterns. Gravity data offer better resolution for much of the region, but some elements of the magnetic field are helpful, even if of lower resolution and reliability of location.

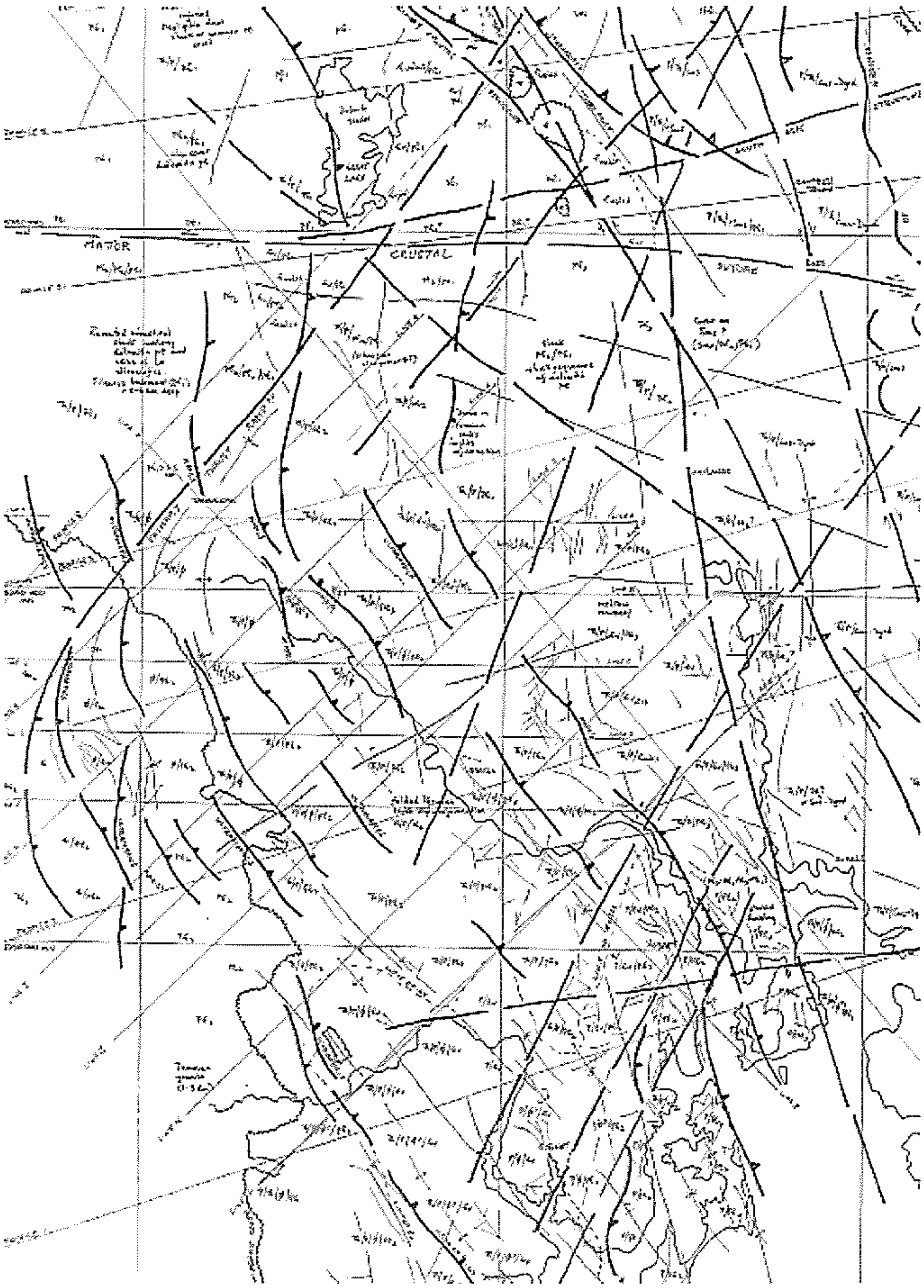

Figure 4: Extract of interpretation summary map, 1991/1992 interpretation of central Tasmania.
Note the inferred thrust character of the entire region. The comments were an attempt to indicate the general location of ultramafics and the lithologies deduced in each block.

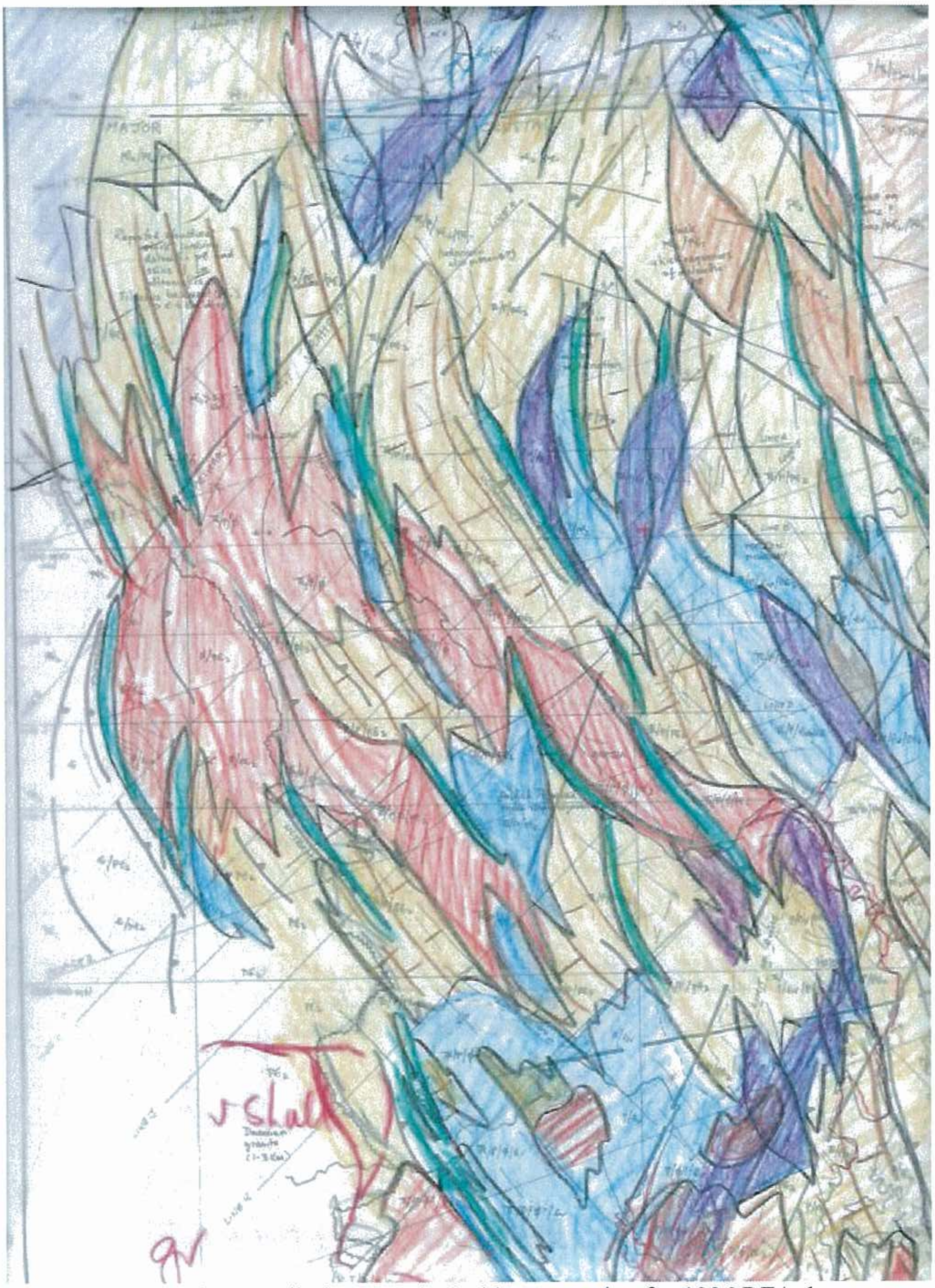

Figure 5: Extract from preliminary undrafted interpretation for 1996 RFA documents. This version has been used so that some geography and elements of the 1991 interpretation can be superimposed. The final version of this map was produced in solid colour with no geographic detail other than grids and does not permit correlation. Note the additional comment in SW corner about recognition of a shallow Devonian granitoid.