

VICTOR PETROLEUM & RESOURCES LTD.

TASMANIAN EXPLORATION LICENCE - 31/80

RENEWAL & PROGRESS REPORT TO NOVEMBER 21, 1981

Licence Holder: Northwest Bay Company Pty. Ltd.

Manager & Operator: Victor Petroleum & Resources Ltd.

Report by: Mr. T.G. Summons

November 27, 1981.

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EL 31/80

SUMMARY

Exploration activities within EL31/80 for the six month period to November 21, 1981, of drilling and defining potential open cutable reserves in the Woodbury area. Assessment of the drilling results indicate a total of 18.7 million tonnes of 40.2% Ash coal using a 10:1 overburden ratio, as measured and first class indicated reserves.

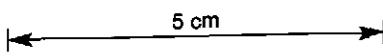
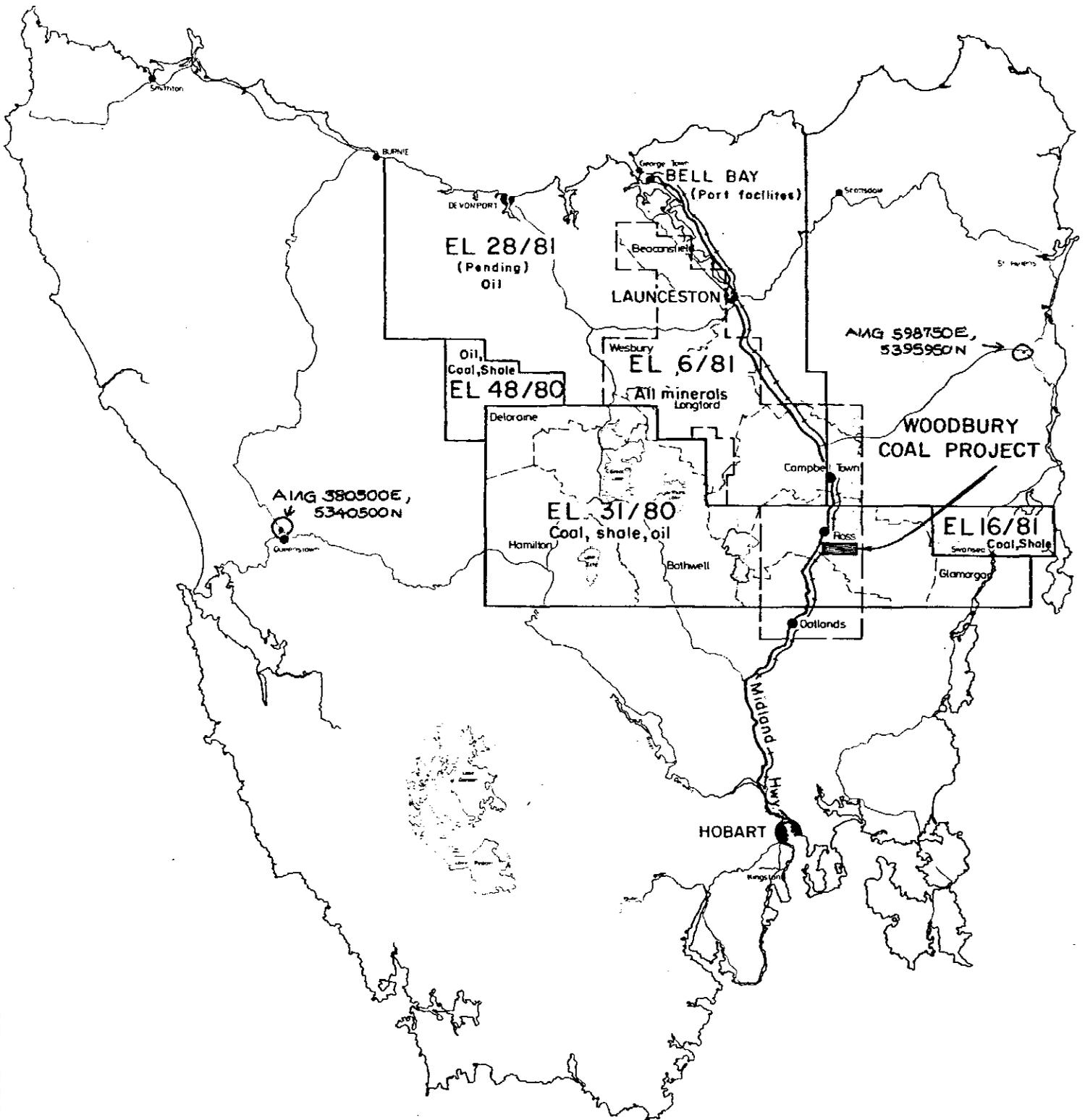
This report describes the additional support activities including surveying photogrammetry, density determinations required to define the reserves.

In addition the gravity survey south of the open cut reserves executed to determine the nature of the dolerite intrusion and field mapping within the licence are also described.

Reports submitted to the Department of Mines during the period include the Quarterly Report in which all basic data relevant to Woodbury was compiled and an interpretation of that data named, the Woodbury Coal Deposit "Definition of the Resource" submitted on October 12, 1981.

Redevelopment activities to include further drilling, washability tests, bulk sampling and a feasibility study are proposed for the Woodbury project. An expenditure of up to \$400,000 will be required to conduct this work, once policy matters in regard to private land and export of the coal are established.

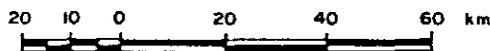
Regional geological mapping, geophysics and scout drilling directed at both coal and hydrocarbon exploration are proposed for the remainder of the Exploration Licence. An expenditure of \$200,000 is proposed.



# VICTOR PETROLEUM & RESOURCES LTD.

LOCALITY PLAN OF

E.L. 28/81 , E.L. 48/80 , E.L. 6/81 , E.L. 31/80 & E.L. 16/81



PROPOSED EXPLORATION PROGRAMME FOR EXPLORATION LICENCE 31/80 FOR  
YEAR ENDING NOVEMBER 21, 1982

Definition of open cut reserves of 18.7 million tonnes of 40% Ash coal using a 10:1 overburden ratio in the Woodbury area resulted in the marking out on 6th November, 1981, of coal leases totalling 1600 hectares.

To determine the viability of the Woodbury Coal Deposit will require additional work, including the following:

- large diameter core drilling
- infill drilling on a 300m x 300m grid of potential mining areas
- washability tests on cores obtained from large diameter drilling
- bulk sampling for pilot scale coal preparation tests
- full feasibility study.

It is estimated that an expenditure of \$250,000 will be required to carry out the above predevelopment work. The timing of a proportion of this expenditure will be related to the granting of the leases and current discussions being held with private land holders, and the Tasmanian Government in regard to the mining and export of coal from the Woodbury Deposit. The proposed expenditure is also intended to be directed at satisfying labour covenants, to be imposed on the granting of the leases.

Additional ongoing exploration activities outside the Woodbury area will consist of further regional and detailed geological mapping, photo-geology and the study of landsat imagery to evaluate and define the extent of the three main known coal horizons within the licence.

The hydrocarbon exploration programme will be directed toward identifying the nature of potential source rocks and whether hydrocarbons have been generated. Particular emphasis will also be placed in the regional assessment to identify the location and existence of potential reservoir rocks, e.g. the Risdon sandstone and potential cap rocks such as the Ferntree group.

Scout drilling for coal and core drilling for unweathered source rock material, and geological characteristics of the reservoir and caprocks is contemplated although justification will need to be established by the geological mapping and sampling programmes.

Infill regional gravity surveys and airborne magnetic surveys may be conducted if required.

An additional expenditure of \$200,000 is proposed to carry out the above proposed exploration programme outside the Woodbury area.

EL 31/80

1.0 INTRODUCTION

Exploration activities during the six month period to November 21, 1981, have consisted of geological mapping, drilling (diamond and rotary/percussion), logging (geological and geophysical), sampling and analysis of coal core, a gravity survey and varied surveying work. A major study of existing geophysical data was undertaken by consultant geophysicist, Dr. D.E. Leaman.

In addition, the liquid and gaseous hydrocarbon potential of the area covered by EL 31/80 was studied, and the conclusions arising from this appraisal have identified those aspects of hydrocarbon exploration in the onshore Tasmanian Basin which require further attention.

A summary of the work performance during the period can be categorised under the following headings.

2.0 MAPPING

2.1 Woodbury Area

The Survey Section of the Hydro Electric Commission (HEC) of Tasmania, was commissioned to conduct a photogrammetric plot of the Woodbury area; the resultant plan produced covered an area of approx. 38 sq. km. and depicted the topography at a scale of 1:5000, with 4m contour intervals. This plan remains to be drafted.

The plan was then used as a base sheet for recording the outcrop geology, air photo linears and all drill hole collar positions.

2.1 Woodbury Area

The results of the mapping indicates that the Woodbury coal measures lithic sandstone have a possible faulted boundary with the Ross Sandstone (quartz sandstone). The boundary between the two sequences occurs approx. 3 km. north of the Woodbury (Glen Morey) road, and strikes WSW. Considerable complexity of the geology of the area has resulted from apparent polyphase intrusion of dolerite sills and dykes. However, the mapping has also indicated the presence of additional areas of coal bearing sequence (lithic sandstone), peripheral to the NW and NE of the Woodbury Coal Deposit. Accordingly, further drilling is planned to fully investigate the coal potential of these areas.

2.2 Woodbury - Tunbridge Area

Photo mapping at a scale of 1:42,000 was completed over an area of approx. 50 sq.kms. located south and east of Tunbridge and east of the Midland Highway (see geological sketch map No. 1 ). The dominant lithologies in this area are Triassic Ross Sandstone, and Jurassic dolerite, with minor Tertiary basalt; regional dips in the area are typically to the south, which is in general agreement with the dip data from the Woodbury Coal Deposit. Further investigations are currently in progress over this area.

2.3 Ross-Macquarie River Area

Photo mapping at a scale of 1:42,000 was completed over an area of approx. 40 sq.kms., east of the Macquarie River and centred on Ross (see geological sketch map No. 2 ).

In addition to the Upper Marine Sequence rocks of the Parmeener Super Group around Ross, lithic sandstone, similar to the Woodbury coal measures lithic sandstone, has been located 2 km. east of Ross.

2.3 Ross-Macquarie River Area (Contd.)

Several drilling targets for coal have been identified south of this locality in an area variably covered by Tertiary basalt and Recent alluvium.

Further work to define both the Triassic coal measures sequence and the Permian Cygnet coal measures sequences correlate is in progress in the area.

2.4 East Woodbury Area

Photo mapping at a scale of 1:42,000 was completed over an area of approximately 150 sq. kms., generally east of the Macquarie River. This mapping has been directed at Parmeener Super Group in tiers in the dolerite and to date, the Faddens Tier and Quoin localities have been examined for both Triassic and Permian coal sequences. Upper Marine sequence rocks of the Parmeener Super Group have been recognized, and the area is currently being reappraised for the potential occurrence of Cygnet Coal Measure correlates. The East Woodbury area contains Parmeener Super Group rocks significantly older than the Woodbury coal measures sequence, and fault movement along the Tamar Fracture System is implied.

3. DRILLING

The core and open hole drilling conducted in the Woodbury area was directed at establishing the existence of open cut coal reserves. All bore hole data including co-ordinates, levels, geology, coal seam geology and geophysical logs, was reported on in the Quarterly Report submitted to the Department on August 28, 1981. A summary of the data is as follows.

3.1 Diamond Drilling

26 holes, totalling 1880.49m of diamond drilling, were completed at Woodbury during the period, of which 210.16m was precollaring and 1670.33m was cored drilling.

3.1 Diamond Drilling (Contd.)

The majority of holes were cored with HQ wireline gear with 2 holes cored partly and 1 hole entirely with NQ wireline gear.

3.2 Rotary/Percussion Drilling

11 holes, totalling 903.00m of open hole drilling were completed at Woodbury during the period. Total drilling during the six month period amounted to 2783.49m.

3.3 Geological Logging

All 37 holes drilled during the period at Woodbury were lithologically logged, amounting to 2783.49m. Written and graphic logs of the 26 diamond drill holes were included in Appendix 1 and written logs of the 11 open holes were contained in Appendix 3 of the Quarterly Report for EL 31/80.

3.4 Sampling and Analyses

3.4:1 Diamond Drill Core

All coal seams intersected in the drilling program at Woodbury (19 holes) were sampled and despatched to S.G.S. Australia Pty. Ltd. in Sydney for proximate analyses and detailed seam logging. This data was contained in Appendix 2 of the quarterly report for EL 31/80. All core is presently stored in the Victor Exploration Pty. Ltd. Campbelltown office.

3.4:2 Rotary/Percussion Samples

All drill holes not collared in dolerite in the Woodbury area had representative 2m samples collected, bagged and stored in the Campbelltown office.

3.5 Geophysical Logging

3.5:1 Diamond Drill Holes

In the Woodbury area, 11 holes, totalling 824.65m, were caliper, gamma-gamma density, natural gamma, and self/potential/resistance logged using a portable SIE T450E logging unit during the period.

3.5:2 Rotary/Percussion Drilling

In the Woodbury area, 9 holes, totalling 687.80m were logged similarly to the diamond drill holes. Total geophysical logging amounted to 1512.45m. Drafted wire line logs of the 20 holes were included in the section appended to the Quarterly Report for EL 31/80 (of which 8 have both geophysical and geological data depicted).

3.6 Density Determinations

Twenty-five samples each of sandstone, mudstone and dolerite from the Woodbury drill core were sent to the Launceston Laboratory of the Department of Mines for density measurements. The results indicate the in situ and broken dry densities to be as follows:-

Sandstone:	2.25 and 1.28	tonnes/metre <sup>3</sup>
Mudstone:	2.36 and 1.27	" "
Dolerite:	2.80 and 1.48	" "

The densities were determined for orientation purposes in reference to the gravity survey and overburden stripping.

4. GRAVITY SURVEY

A gravity survey covering an area of approx. 53 sq.kms. at Woodbury was completed during the period. The gravity survey was designed to provide information on the nature and mode of occurrence of the dolerite mass to the south of the Woodbury Coal Deposit. The survey area consisted of approx. 33 sq.km. of detailed coverage (average station spacing of 400m), and approx. 20 sq.kms. of random (spot height) coverage marginal to the area of detailed survey.

Gravity readings consisted of 176 on grid stations, 152 on random stations and 21 spot height stations, totalling 349 stations.

Interpretation of the results by Dr. D.E. Leaman is currently in progress, and a preliminary appraisal of the data suggests a dolerite feeder to the SE of Black Tier, with at least one dolerite sill to the immediate south of the Woodbury Coal Deposit.

5. SURVEYING

5.1 Drill Holes

All 37 holes drilled during the period were surveyed for both collar position and elevation and tied to the State grid.

5.2 Gravity Stations

Surveyed grid lines (48.5 line km) with gravity stations ranging from 100m to 400m spacing, were established during the period; following this, 349 gravity stations were levelled and linked to the State grid.

5.3 Photogrammetric Plotting

The Survey Section of the HEC was commissioned to produce a photogrammetric (machine) plot of an area of 38 sq.km. at Woodbury. The reason for initiating this survey was to facilitate the calculation of overburden volumes in open cut mining feasibility studies. The plan produced by the HEC was drawn at a scale of 1:5000, with 4m contour intervals.

6. WOODBURY OPEN CUT COAL RESERVES

The coal reserve (measured and first class indicated) at Woodbury, assessed as being amenable to open cut extraction using a 10:1 stripping ratio is 18.7 million tonnes containing 40.2% ash. Further details re the Woodbury Coal Deposit are contained in a report titled "Woodbury Coal Deposit - Definition of the Resource", submitted to the Department on October 12, 1981.

7. REGIONAL GEOPHYSICAL DATA APPRAISAL FOR EL 31/80

Consultant geophysicist, Dr. D.E. Leaman, investigated the available data (predominantly State and Federal governmental) pertinent to the area covered by EL31/80 and compiled a report titled "Review of Geophysical Information for EL31/80, 6/81 and 16/81". This report is included as Appendix 1.

8. HYDROCARBON POTENTIAL IN TASMANIA

Sedimentary rocks ranging from Palaeozoic to Mesozoic in age were viewed in the context of being potential hydrocarbon source, reservoir and trap lithologies. Two potential/actual sources rocks assemblages were identified, the Ordovician Gordon Limestone (carbonate), and the Carboniferous-Permian, Lower Marine Sequence Parmeener Super Group (clastic). Complete details are contained in the appended report titled "Preliminary Report on Petroleum Potential - Onshore Tasmania", Appendix 3.

# Victor Petroleum & Resources Ltd.

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EMA:jlb

November 27, 1981.

Department of Mines,  
G.P.O. Box 124B,  
HOBART, Tas. 7001

## Exploration Licence 31/80

### Statement of Expenditure for Quarter ended 31st October, 1981

	<u>Total to</u> <u>31.7.81</u>	<u>1.8.81 to</u> <u>31.10.81</u>	<u>Total</u> <u>to Date</u>
1. Salaries & Consulting Fees	\$129,702	\$38,254	\$167,956
2. Travel & Accommodation	34,965	3,764	38,729
3. Operation & Field Expenses	84,459	6,118	90,577
4. Administration	40,720	14,842	55,562
5. Geochemical Analyses	1,677	8,783	10,460
6. Geophysics Contracts	3,565	8,001	11,566
7. Drilling	255,689	(20,531)	235,158
	<u>\$550,777</u>	<u>\$59,231</u>	<u>\$610,008</u>

### Statutory Declaration

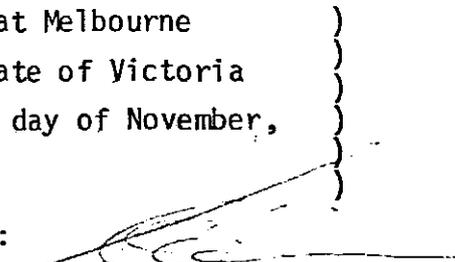
I, Ernest Maxwell Allen of 1 Dale Street, Deepdene 3103 Melbourne in the State of Victoria, do solemnly and sincerely declare that to the best of my knowledge and belief the above statement of expenditure fulfils the requirements of Schedule "A" (Revised), Conditions of the Special Prospectors' Licences and Exploration Licences under the Mining Act, 1929.

And I make this solemn declaration conscientiously believing the same to be true and by virtue of the provisions of an Act of the Parliament of Victoria rendering persons making a false declaration punishable for wilful and corrupt perjury.

Declared at Melbourne  
in the State of Victoria  
this 27th day of November,  
1981.

*E. M. Allen*

Before me:

  
A Commissioner of the Supreme Court  
of Victoria for taking Affidavits.

EL 31/80

- Appendix 1: Review Report - Geophysical Information  
EL 31/80, EL 6/81, EL 16/81  
by Leaman Geophysics
- Appendix 2: Density Measurements of the Main Rock Types  
in the Woodbury Area.
- Appendix 3: Preliminary Report on Petroleum Potential  
- Onshore Tasmania  
by T.G. Summons
- Appendix 4: Report, Prefeasibility Study & Coal Valuation  
of Woodbury Coal Project, Tasmania  
by Dames & Moore

REVIEW REPORT:

GEOPHYSICAL INFORMATION

E.L. 31/80, E.L. 6/81, E.L. 16/81

BY:

LEAMAN GEOPHYSICS

FOR:

VICTOR PETROLEUM & RESOURCES LTD.

July 1981



ABSTRACT

Most previous geophysical surveys, whose coverage overlaps exploration licences 31/80, 6/81 and 16/81, have utilised gravity or magnetic methods. Although the coverage is only partial for each method, or variable in quality and specification, it is possible to form some structural conclusions by integration:

- i) A Cambro-Ordovician basement is general for large parts of the region.
- ii) The thickness of post Carboniferous rocks nowhere exceeds 1 - 2 km.
- iii) Basement rocks occur within 400m. of the surface in the Winkleigh-Glengarry region northwest of Launceston and in an arc around the foot of the Western Tiers.
- iv) Basic or ultrabasic rocks are included in the basement sequence.
- v) Dolerite feeders can be identified in the region of Moulting Lagoon (EL 16/81) and Great Lake (EL 31/80).

Magnetic surveys are recommended for parts of each licence area. In the case of 31/80 these should provide an improved guide to all types of structures and in the case of 6/81 the areas selected may contain mineralised rocks. The surveys are there intended to estimate the Cambrian content and evaluate the lithologies present. Some accessory supporting gravity coverage is recommended so that an integrated and less ambiguous interpretation is possible.

INTRODUCTION

Victor Petroleum and Resources Ltd. are engaged in exploration of three licence areas in Tasmania (see Figure 1). Two licences are for coal, oil, shale (EL 31/80, EL 16/81) while the third (EL 6/81) is an all minerals licence.

Although a near surface coal deposit is currently under evaluation near Woodbury in the upper Midlands - (part of EL 31/80) and the exploration programme is currently somewhat biased by this activity substantial surrounding areas await assessment. Geophysical techniques, in association with known geological mapping, offer the most rapid and economical means of making such an assessment. However, the scale of areas licenced, the variability of the geology covered and the range of potential target objectives makes method selection and specification difficult.

Consequently, prior to commencement of new surveys a review of extant data was suggested. Although it was realised that such data might be scanty or inadequate for a variety of reasons it was believed that some useful information might be gleaned directly. Or, that subsequent surveys could be appropriately specified or located and restricted.

This report examines the various exploration objectives and reviews the available geophysical data in respect of those objectives, survey specification and coverage. Several re-interpretations and some new interpretations are included which suggest some areal restrictions for future surveys. Much of the existing information has not been interpreted previously.

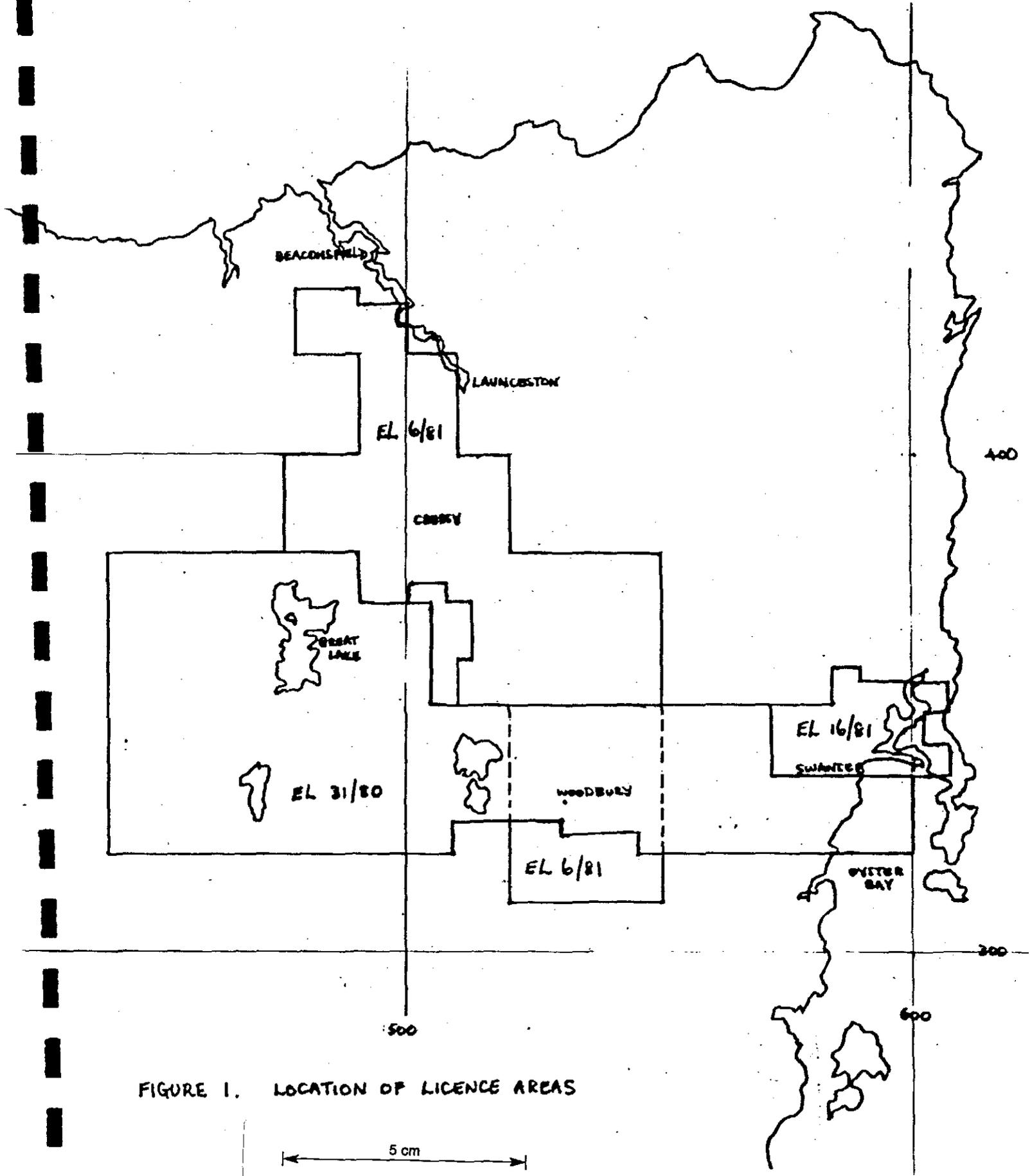


FIGURE 1. LOCATION OF LICENCE AREAS

EXPLORATION OBJECTIVES

At the initial stages of exploration, particularly where large areas are to be appraised and the geology and licence conditions are diverse, a range of objectives can be anticipated.

EL 31/80 covers a large portion of the Central Plateau and upper Midlands of Tasmania. Its geology is dominated by dolerite exposures and related structures - at least near surface. Permian and Triassic rocks are also exposed and some of the latter are coal bearing. Significant amounts of Tertiary basalt are also present in the plateau portion of the area. The eastern side of the Western Tiers escarpment passes across the centre of E.L.

EL 16/81 is relatively small and may be considered an extension of EL 31/80. Tertiary basalts are rarely found but thick Tertiary deposits occur in the region of Nine Mile Beach.

EL 6/81 covers a large part of the West Tamar region south of Beaconsfield, the Longford-Cressy Tertiary basin and part of the upper Midlands from Oatlands to Campbell Town. The geology is diverse but generally dominated either by dolerite-related structures (in the south) or Tertiary structures or sediment (in the centre). In the north Cambrian and Ordovician rocks are overlain by Permian rocks. Large areas of Triassic exposure occur where EL 6/81 overlays EL 31/80. (EL 6/81 is the all minerals licence).

Selection of potential target areas depends largely on the nature of the resource sought.  
Coal: Some coal measures are exposed (e.g. Woodbury) but the extent of any deposit is rarely obvious due to the effects of concealed faulting and dolerite cover. It is essential that dolerite structure and especially local thickness variations be assessed since seams may be terminated or altered. In addition drilling costs and risks may be minimised by appropriate site selection. Dolerite thickness variations may be directly related to variations in total thickness of the sedimentary sections since dolerite intrusion may have truncated or dilated some sections. Thicker or more complete sections may be more productive (contain more seams).

Oil, Shale: It has been argued that thick sections of Permian rocks may contain coal or oil shale similar to, or more extensive than, deposits elsewhere in Tasmania but little is known about the Permian succession south of the Great Western Tiers. In addition, definition of the basins of deposition for the Permian rocks, and the form and composition of the pre-Permian basement may be relevant to such propositions. The possibility of some 'basement' units being source rocks or gas carriers cannot be excluded.

Thus for EL 31/80, EL 16/81 any reconnaissance surveys should seek to assess :

- i) dolerite sheet variations, in particular where it is thinnest. Such zones may then be matched with known or suspected coal measures distributions.

- ii) thickest sedimentary sections which may be reviewed for Triassic coal or Permian coal/shale objectives, and
- iii) the overall form of the Tasmania basin (post Carboniferous deposition) and the possible content and structure of the Lower Palaeozoic rocks beneath it.

Objectives (ii), (iii) are regional in scale while (i) may require considerable detailed expansion after the initial work.

Minerals: Selection of target areas within EL 6/81 may be related to two types of mineralisation:

1. In Lower Palaeozoic rocks, especially Cambrian rocks, with a style comparable to that in western and north-western Tasmania. Although some Cambrian rocks are exposed definition of sub-surface extent and variation is required. Initial evaluation is to be restricted to within 300 - 400 m. of the surface and thus involves location of those areas where post Carboniferous materials are less than 400 m. thick. Subsequent detailed investigation may be required to assess any possible mineralisation directly.
2. Sedimentary concentrations in either Triassic or Tertiary materials. Minerals or elements present may include chromite, gold, tin or uranium and other radioactive materials. Little is presently known of the likely extent or composition of such concentrations.

APPLICABILITY OF GEOPHYSICAL METHODS

Most of the objectives described above reduce to a comprehensive structural analysis, including evaluation of dolerite features, faulting, thickness of major units and basement configuration. An indication of basement composition would be desirable. The methods most suited to such an appraisal, given the diverse and disrupted geology of Tasmania and the scale of the E.L. areas, are gravity, magnetics and possibly seismic reflection although the latter is better employed after the reconnaissance is completed.

The primary difficulty with the gravity and magnetic methods is coverage vs resolution. The resolution of the potential methods is directly proportional to the station or line spacing and where large areas are to be covered quickly gravity surveys are inappropriate. Magnetic surveys (airborne form) overcome some of this difficulty by being relatively cheap and rapid but rarely yield the same amount of information as a gravity survey. Where possible both, or several, methods should be integrated.

Both methods (gravity/magnetics) have established feasibility in respect of most structural objectives (as defined in the previous section) and this review is intended to indicate regions for more concentrated application.

The assessment of sedimentary mineral concentrations is a much more difficult proposition geophysically since it depends on much knowledge of the mix and properties of the concentrations. If it can be established that radioactive materials are present then appropriate combinations of scintillometry or radiometric spectroscopy may be specified although the areas covered may need to be very restricted. Clearly, considerable geological ground work is required before committing funds to radiometric geophysics. Chromite-bearing deposits, however, could be expected to yield small but useful magnetic anomalies. Ground surveys may be the most appropriate means of assessing all types of mineral concentrations - depending on properties yet to be defined.

It should also be noted that ground magnetic methods are a proven means of removing some uncertainties from geological mapping where dolerite boundaries are concealed by soil or talus, or for the identification of dolerite talus. In many situations dolerite and dolerite talus are not easily distinguished by the mapper (see Leaman & Richardson, 1980b).

SUMMARY OF AVAILABLE DATA AND INTERPRETATION REVIEWGENERAL:

Most of the area covered by EL 31/80, EL 6/81 and EL 16/81 has never been actively explored. Where exploration licences have been held in the past most assessments made have been geological reviews or photo-interpretations. Consequently little geophysics of company origin is available for review. Where data is available from this source it is usually accidental with very different objectives or coverage from that required for this project. Most data is of government origin - either Bureau of Mineral Resources (BMR), Canberra or Tasmanian Department of Mines.

Each survey has been examined in some detail and interpreted or re-interpreted where necessary or possible. The interpretations given are not complete, but are specific to the objectives listed on page 2.

SEISMIC, ELECTRICAL AND LOGGING SURVEYS:

A number of ground magnetic, resistivity and refraction surveys have been undertaken around Launceston (EL 6/81) and the Central Plateau (EL 31/80). Most have been directed at problems of foundation or tunnel engineering and they are not listed here. A complete list is included in Leaman (1980). The surveys, however, indicate the following rock properties data:

	Velocity (m/s)	Resistivity (ohm-m)
Soil	<800	<300
Talus	800 - 1600	15 - 1000+
Tertiary sediments	1600 - 1800	0.1 - 300 <sup>a</sup>
Tertiary basalt	1500 - 6000 <sup>x</sup>	25 - >10000
Jurassic dolerite	1500 - 6000 <sup>x</sup>	25 - >10000
Triassic rocks	2000 - 3500 <sup>x</sup>	10 - 1000 <sup>b</sup>
Permian rocks	2500 - 4500 <sup>x</sup>	15 - 5000 <sup>b</sup>

+ depending on clay/matrix proportion

x depending on fracturing and weathering

dependent on state of weathering

a dependent on clay content or water salinity in various beds

b dependent on weathering or more usually water content

The tabulated values suggest that reflection techniques are viable since velocity contrasts are substantial. Unfortunately, test traverses in the Fingal and Seymour regions in eastern Tasmania (Richardson and Leaman, 1980 and 1981) have established that the method is currently usable only in those areas where dolerite is not exposed at surface. It appears that jointing, or more precisely joints above the level of relaxation, attenuate the signal and modify its energy spectrum. The problem is soluble using small charges, high resolution digital recording techniques, single geophones and a very careful trace by trace velocity-corrected processing method. Few commercial processing centres are prepared to manipulate data in this way and processing costs may be very high.

No comprehensive seismic reflection surveys, either as sets of soundings or traverses have yet been undertaken within any of the E.L.s under review. Only one set of three isolated, unprocessed soundings have been recorded - along Nine Mile Beach in EL 16/81 - and the results have been reported by Leaman and Richardson (1981b, page 32). The soundings provided an independent assessment of the large gravity anomalies found in the region and were able to resolve basement (dolerite or Permian rocks) under a substantial cover of Tertiary sediments.

Trial reflection traversing at Seymour, north of EL 16/81, on exposed coal measures has demonstrated the value of the method for the tracing of shallow seams and the location of faults. Throws of only a few metres were recognisable.

Down hole logging, to a depth of 300m, was undertaken on a regular basis during the groundwater assessment of the Longford basin by the Department of Mines. Unfortunately the range of sondes used was limited to single point resistivity, self potential and gamma-gamma and although suited to the resolution of aquifers, fresh/salt water or clay beds the combination did not yield data relevant to possible placer or mineral concentrations since limited quantitative calibration control was applied.

#### MAGNETIC SURVEYS:

Three aeromagnetic surveys have covered parts of the review area and each is examined individually with respect to the general exploration objectives stated on page 2.

##### 1. Regional high altitude survey

Source: Bureau of Mineral Resources (BMR)

Reference: Finney and Shelley (1967)

Altitude: 10000 feet

Line Spacing: 10 nautical miles

Position accuracy: 1 - 2 miles

Comment: Few traverse lines apply to the areas under review. The coverage is generally adequate to infer only principal structural features but some useful magnetic character is evident on some lines.

A reproduction of the relevant portion of the survey is shown in Figure 2. Each traverse line is shown in true relationship to the geography. Magnetic profiles, with a relief of about 150 nT (gammas) are shown above the appropriate line. Each traverse is numbered and associated with a township in order to aid positioning. The profiles have been included in this review as they provide the only coherent magnetic data for all licence areas.

Only traverse line 2 was interpreted in the original report and then only in terms of deep crustal features. The other traverses were all grouped as Zone B, "corresponding to the area of outcrop of the Jurassic dolerite" and "characterised by high frequency magnetic disturbance" (p.5, op cit).

A qualitative inspection of the profiles reveals that the simple surface geology - profile character relationship implied by Finney and Shelley is incorrect. Consider, initially, lines 4 to 7. Dolerite is exposed along most of these profiles and yet the magnetic character rarely reflects surface materials or dolerite structures. There is no clear indication of the thickened intrusion at the north end of Great Lake (line 4 contrasted with Jones, Haigh & Green 1966) and no obvious reason for the large anomaly south of Oatlands (line 7) where little dolerite is exposed. In addition there is no consistent relationship between topographic features and magnetic field - especially where the topography is dolerite dominated. Only (t), line 4, is possibly a terrain induced anomaly. A similar effect could have been expected on lines 5 and 6.

Higher frequency magnetic disturbances are relatively localised and do not correlate with dolerite exposures. Consider line 4. West of (t), on the plateau, high frequency anomalies have been observed, but east of Conara - again over dolerite - they are non-existent. A similar behaviour may be observed on line 5. In this case localisation of the high frequencies to the Great Lake region is apparent. The plateau west of Great Lake and the Eastern Highlands (east of Ross) yield similar magnetic characters. Lines 6 and 7 display the same character although the geology covered by line 7 is more varied. Even so there is no simple correlation between magnetic field, exposed dolerite or exposed Permo-Triassic rocks.

Thus while it is possible that the high frequency behaviour of the magnetic field south of Great Lake may reflect thickened dolerite (by a factor of 2 - 4) it is possibly also a reflection of basement features. Indeed, many of the anomalies - such as that near Great Lake on profile 5 - are compound. This conclusion is re-inforced by the major anomaly north-east of Cressy, on line 3.

Line 3 traverses the major Tertiary basin in northern Tasmania. It might be expected that the variable but often thick Tertiary cover (50 - 600 m.) would have a profound effect on recorded anomalies. No such effect is noted. There is little obvious correlation between anomaly and cover except at (f), the primary fault in the region. The anomaly becomes increasingly negative as the Lower Palaeozoic basement is approached south of Deloraine. The large anomaly north-east of Cressy lies on the Mt. Arnon - Hummocky Hills trend with elevated dolerite. However, the gravity survey of the area (Longman and Leaman, 1971) shows that the dolerite basement is depressed, or even absent, in this zone. The source of the anomaly must lie in the Palaeozoic basement.

A major basement structure is implied on lines 4 to 7 along a gentle arc from Conara - Ross - Oatlands. The broad anomaly near Conara splits and narrows to the south and disappears rapidly to the north. The feature on line 3 is a remnant. Similar features recur west of the Tamar River at Beaconsfield in association with ultra basic rocks (profile not included).

The sense of many of the anomalies described is critical to their interpretation and must reflect the magnetisation of the sources since many anomalies are larger than would be produced by susceptibility induced effects alone unless the content of iron oxides was abnormal. In either case the characteristics of the field are consistent with magnetised basic rocks. This is in marked contrast to the effect produced by other Lower Palaeozoic rocks wherever encountered.

Precambrian, Cambrian and Ordovician rocks exposed west of Glengarry (line 1), south west of Deloraine (line 3) and east of (t) on line 4 have produced a decreased magnetic intensity. A similar effect is apparent at the eastern end of line 4, as presented, and the eastern end of line 5. In addition the smoothed profiles west of Great Lake (lines 5,6) and diminished anomalies at the western end of line 7 appear to be related to Lower Palaeozoic and Precambrian basement rocks.

The interpretation thus far may be summarised:

- a) dolerite bodies, unless exceptionally thick, do not contribute significantly to the magnetic field at 10000 feet.
- b) a belt of strongly magnetised material possibly ultrabasics, extends south east from Beaconsfield then north-south from Conara to Oatlands. The lineament is disrupted in the Launceston area.
- c) the disturbed magnetic field around Great Lake and to its south reflects both thick dolerite and a basement structure probably similar to (b), but with a broadening extent from north to south. The Adamsfield exposures to the SSW are encompassed by this trend.
- d) Lower Palaeozoic and Precambrian rocks appear to be differently magnetised and recognisable by low magnetic field observations.
- e) moderate, or slightly elevated, values reflect regions in which the Tertiary or Permo-Triassic cover is substantial (>500m.). For example, line 3 east of (f), lines 5 and 6 west of Ross and line 6 east of Ross.

If these deductions are applied to the few remaining features in the profiles it may be concluded that basement rocks (reflected by very low anomalies) sweep around the Tiers (from east of (t) - line 4) to the western end of line 3 and also trend north westerly from line 4 - through (f) line 3 across line 2 to the western end of line 1. Lines 5 and 6 show little evidence of basement but line 7 implies basement at relatively shallow depth both east and west of Oatlands. When these anomalies are located on a geological map it is found that they correlate with uplifted blocks of Permian rocks and the likelihood of elevated basement is supported.

Concluding, then, the interpretation -

- f) Lower Palaeozoic - Precambrian basement extends south east from Glengarry - Deloraine but is absent east of a line down the Tamar River and about midway between Oatlands and the east coast. The basement includes basic intrusives (b, c) and appears to bifurcate between Cressy and Deloraine.

Depth to basement is not easily resolved due to the level of survey and definition of results. Many anomalies are also compound. An additional problem relates to the magnetisation properties which are presently unknown. However, many are within a kilometre of the surface.

## 2. South West Tasmania regional survey

Source: Broken Hill Proprietary Co. Ltd. (BHP), 1966  
Reference: Tas. Department of Mines open file "Regional 6"  
Altitude: 500 feet (presumed)  
Line spacing: 300 - 1000m, 500m nominal  
Comment: Only the south western corner strip of EL 31/80 is covered by the survey (between 440000 and 490000m. E and 5320000 and 5330000m. N). This portion of the survey is dominated by dolerite anomalies and was of little interest to the originating company. No interpretation was produced.

As noted above, the survey was flown at a much lower elevation than the BMR coverage and the near surface effects of dolerite do dominate, yielding a complex magnetic texture.

Unfortunately the data has been presented at a scale of 1:250000 with a small but unrecognisable, contour difference. No contour values can be discerned. The presentation was appropriate to the magnetic quietness of much of south-west Tasmania but quite unsuited to dolerite-covered areas. No quantitative interpretation of the data is possible because profiles cannot be produced from the map. Some qualitative interpretation is possible based on spectral variations.

Three types of field character can be observed:

- i) very quiet with low gradients related to Permo-Triassic rocks,
- ii) small variations with gentle gradients related to Tertiary basalts or weathered dolerite, and
- iii) large localised variations with high gradients related to exposed dolerite.

The descriptions cannot be quantified. There is also some suggestion of gross, superimposed anomalies with a wavelength of 5 - 10 km. trending approximately north-south. This suggests that appropriate filtering of magnetic data, either by digital processing or flying at higher elevations (compare BMR high altitude data), can separate the contributions due to surface dolerite, however thick, and basement. The gross features are recognisable in the BMR data.

## 3. Offshore Tasmania regional survey

Source: Electrolytic Zinc Co. Ltd. (1967)  
Reference: Tas. Department of Mines open file "Offshore 88"  
for E.L. 17/65  
Altitude: 1500 feet  
Line spacing: 2 - 3 km.

Comment: The survey was directed at the continental shelf and major bays such as Oyster Bay. There is coverage of the eastern half of E.L. 16/81 and a limited interpretation was attached for this region.

Fifteen anomalies within the area of E.L. 16/81 were interpreted for the original report. Unfortunately few of the depths to magnetic 'basement' were compared with topographic or bathymetric maps and many are obviously inaccurate. For example, one nearly two-dimensional anomaly at the centre of the Nine Mile Beach spit was interpreted as having its source at + 500 feet (150 m.) Other anomalies, especially those onshore, have been treated poorly. The problem probably relates to assumptions made about the source material and the type of model chosen.

Re-interpretation of the spit anomaly, for example, presuming dolerite as the source with a relatively low susceptibility ( $\sim 3000 \times 10^{-6}$  SI units) and at least matching natural remanent magnetisation (NRM) a depth below the aircraft of 625m. is implied. This places the body at about 125m. below sea level which compares well with the value of 75+m. suggested by seismic reflection sounding (Leaman & Richardson, 1981). The low value used for the susceptibility of dolerite in this area was based on measurements from the Fingal region (Leaman & Richardson, 1980). Other calculations have presumed values in the range  $2000 - 10000 \times 10^{-6}$ SI and a Koenigsberger ratio of 1 - 5 although there is little supporting evidence for the latter choice (lack of data). The Koenigsberger ratio relates the natural remanent and induced magnetisation of a material and indicates the relative dominance of the NRM component which may be differently oriented to the inducing field.

Using these values, magnetic basement generally occurs within 200 - 400 m. of sea level in the northern part of Oyster Bay. Dolerite is presumed. A similar situation has been deduced around Moulting Lagoon. Two areas are exceptional, one is centred at 595000m. E, 5336000m. N and the other extends from a little north-east of Swansea inland along the line of the Swan River to Cranbrook. Anomalies are more diffuse and either a deeper basement is implied or the basement is no longer dolerite. Basement depth is not easily resolved but lies in the range 300 - 800 m.

Insufficient detail and coverage of the anomalies onshore west of Swansea is available to allow comment on sub-dolerite features. The E.Z. survey also covered the Freycinet Peninsula and it is possible to assert that the magnetic basement in the Oyster Bay region is not Permian rocks, Mathinna Beds or granite.

#### GRAVITY SURVEYS:

Four major and two minor gravity surveys are of relevance to this review.

1. BMR regional helicopter survey  
 Source: Bureau of Mineral Resources  
 Reference: Zadoroznyj (1975)  
 Station spacing: variable. The compilation included any previous work (e.g. surveys 2, 3 and 5) but where none existed the spacing is nominally 7 km.

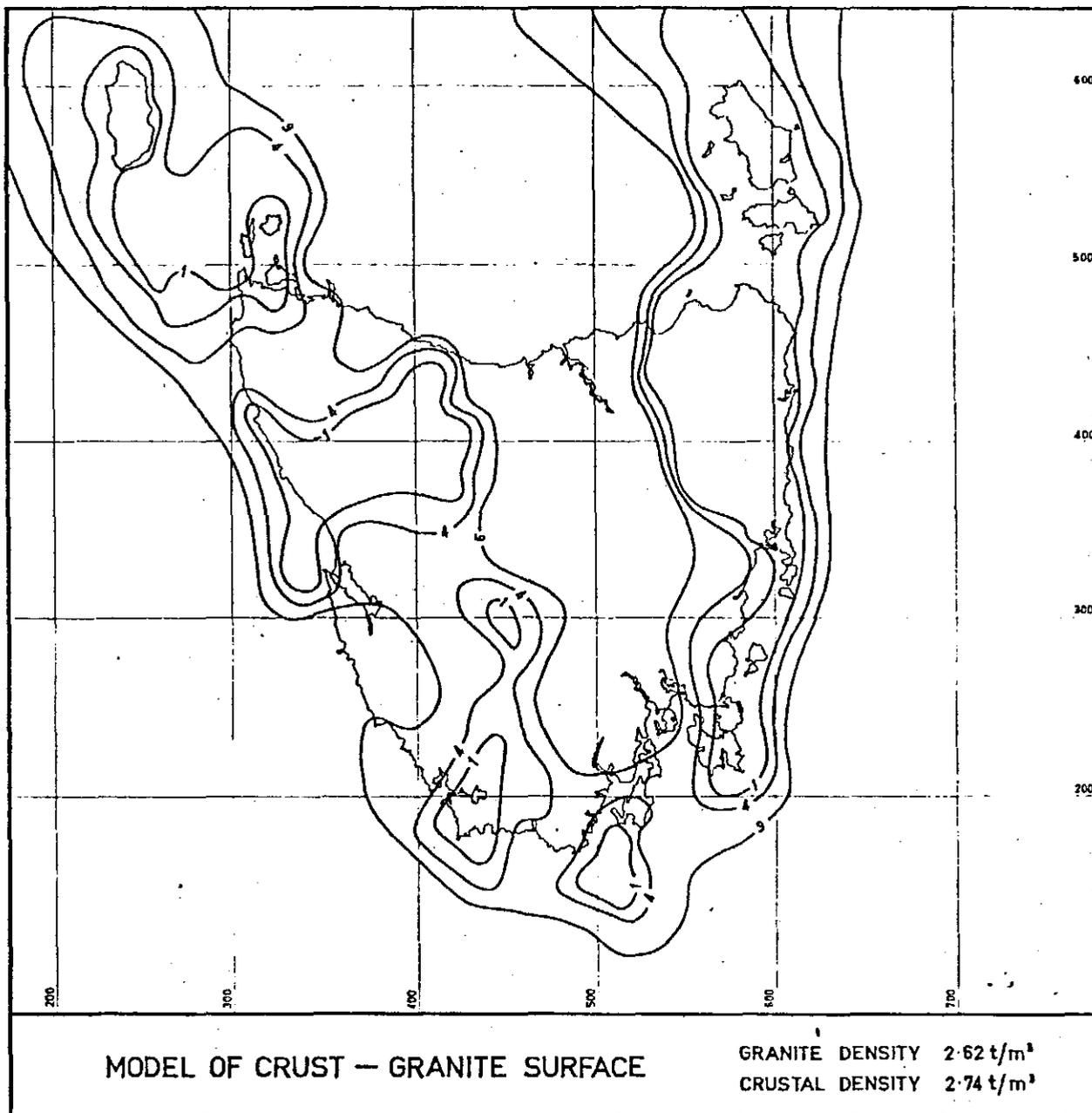


Figure 8.

5 cm

Comment: The survey was part of an Australia-wide compilation and only a very shallow qualitative interpretation was provided.

This survey was reprocessed and interpreted on a crustal scale by Leaman, Richardson and Shirley (1980). It provides the only gravity data over EL 31/80 and much of EL 6/81.

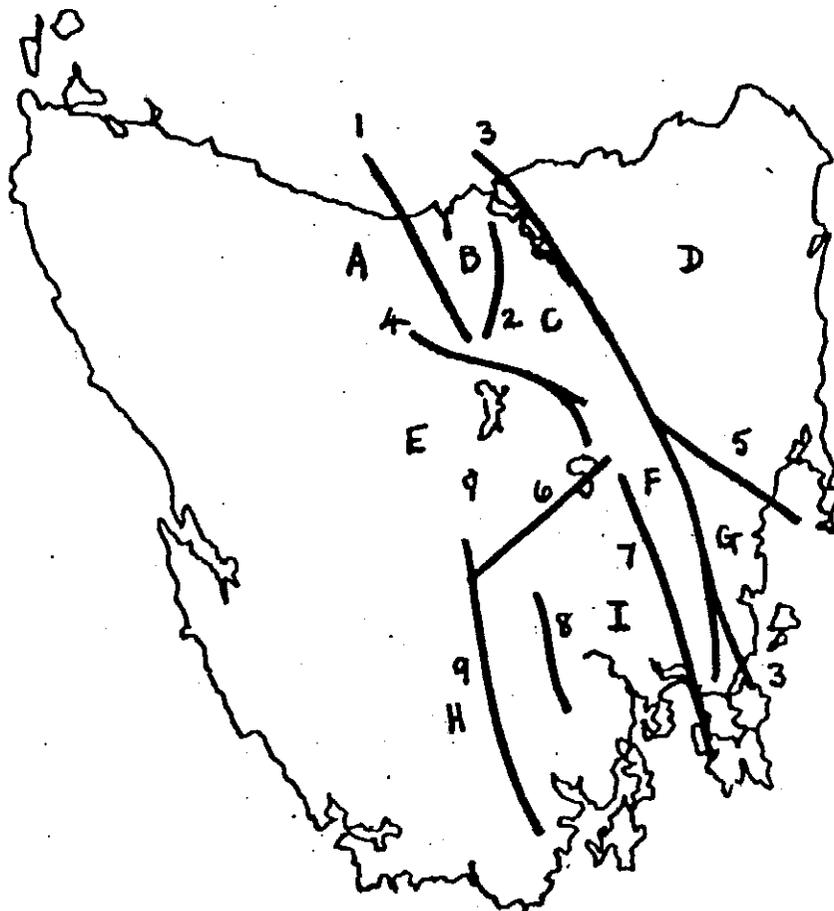
The crustal interpretation suggests that, with the exception of most of EL 16/81, basement is composed of Lower Palaeozoic and Precambrian rocks. Devonian granite, exposed between Bicheno and Schouten Island and proven to lie at depths of 100 - 300 m. between Llandaff and Bicheno forms the basement for most of EL 16/81 and is never more than 1 - 1.5 km. below the surface (see also Leaman & Richardson 1981). The crustal interpretation (reproduced as Figure 3) suggests that granitic basement is at depths in excess of 6 - 8 km. near grid line 550000m. E (about 20 km. east of Oatlands). The interpretation makes no suggestion as to the content of the pre-Permian materials beneath the centre of the island other than that they have a bulk average density of  $2.74 \text{ t/m}^3$ . This density implies a section containing volcanics and complex metamorphics with densities of  $2.70 - 2.80 \text{ t/m}^3$  associated with siliceous rocks such as quartzites or sandstones ( $2.60 - 2.70 \text{ t/m}^3$ ).

Neither the interpretation of Zadoroznyj (1975) nor Leaman et al (1980) considered any shallow basement sources (<2 km.) or basement composition variations within the areas covered by EL 31/80 or EL 6/81 and the data has been reviewed with this objective. The comments below are general and more specific comments may be provided where detailed surveys overlap. (see relevant surveys).

Leaman et al (1980) have produced a series of filtered versions of the gravity data and examination of these suggests several discrete provinces within the basement of the Tasmania basin. The Tasmania basin is often defined as the environment in which the Permo-Triassic rocks were deposited and having a north-south axis across central Tasmania. This description is compatible with the first order gravity interpretation (Figure 3) and correlates with the non granitic crust in the centre of Tasmania.

Several important gradients may be noted in the 10, 20 km. filters and residuals based on the 10, 20, 30 km. filters. The features are shown in Figure 4 but are not well defined south of an east-west line through Great Lake since the bulk of the southern coverage is provided by uncorrected helicopter stations with a 7 km. spacing. Resolution and recognition of anomaly continuity is impaired. For example, it is possible that features 4, 6 and 9 form a single feature, that 4 and 7 and 4 and 5 are related, or that 1 and 8 and 2 and 9 are related. Although close relationships cannot be confirmed with the available data some inferences can be made.

- i) Zone A represents Lower Palaeozoic rocks with up to 6 km. of Cambro-Ordovician material overlying Precambrian rocks.
- ii) Zone B reflects the uplifted Precambrian basement in the Badger Head region.
- iii) Zone C probably contains material comparable to A.



5 cm

FIGURE 4  
BASEMENT TRENDS

- iv) Zone D is the granite - Mathinna Beds province of north-east Tasmania.
- v) Lineaments 1 and 2 represent major basement disruptions and may have north-south continuity across the island.
- vi) Lineament 3 is a major crustal feature and although diffuse in terms of Bouguer anomalies south of F it may be recognised in gravity gradients.
- vii) Zone E is probably an extension of the Precambrian Tyennan Block core. Its shape may be delineated by lineaments 4, 6 and 9. This would imply a section including Lower Palaeozoic rocks in A, C, F and I. These have been mapped in A, C and the southermost part of I and drilled at Glenorchy, north of Hobart.
- viii) Zone H appears to reflect an elevated Precambrian basement with thinner Palaeozoic cover.
- ix) Zone G, based on exposures at Maria Island and Tasman Peninsula appears to be a variant of D, with generally deeper granitic basement (see also Figure 3).

Some attempts have been made to estimate the scale of the lineaments, the thickness of post-Permian cover and the depth to some anomalous features. In general, the coverage is insufficient to specify post-Permian cover to better than 1 km., but lineaments 1, 3 and 9 penetrate 9 - 15 km. of crust and are therefore principal structures. Both 1 and 3 have experienced movements throughout their history and are currently disguised by Tertiary features which bias the Bouguer anomalies. Structures 5, 7 and 8 have a scale of 2 to 5 km. and 6 appears comparable. It is therefore likely that up to 5 km. of Lower Palaeozoic materials overlie Precambrian rocks in Zones F and I (comparable with A) and that their depth is generally less than 1 km. below the present surface. At Hobart, the depth is 600 m.

## 2. Tamar regional survey

Source: Tasmania Department of Mines

Reference: Leaman, Symonds and Shirley (1973)

Station spacing: 1.5 km.

The survey covers the northern section of EL 6/81 and is the first survey treated in this review which contains data able to resolve shallow basement (pre-Permian) structures.

Positive anomalies (residual Bouguer anomaly) are associated with shallow or exposed basement rocks (Ordovician or Cambrian), or thick dolerite sheets. Negative anomalies are associated with thick sections of Permo-Triassic rocks and Tertiary sediments. Small negative anomalies (0 to -2 mgal) are often observed where thick sections include some dolerite.

If those areas in which post Carboniferous materials exceed 400 m. are to be excluded from consideration all regions of negative anomaly are automatically excluded. In addition, those areas where dolerite is exposed, the relief is moderate - confirming at least 100 m. of dolerite - and the anomalies do not exceed +1 or +2 mgal may also be excluded. This was demonstrated in Section DE of Leaman et al (op cit).

East and south of Legana and west of Launceston the anomalies are related to thick Tertiary deposits (up to -6 mgal, equivalent to at least 250 m.) with a terrain including dolerite sheets and Permo-Triassic rocks. Near Trevallyn, immediately west of Launceston, the section (excluding any Tertiary component) includes 100 - 350m. of dolerite and up to 600m. of other rocks (principally Permian).

Near Beaconsfield where Cambrian and Ordovician rocks are exposed the anomalies range from -2 to +5 mgal; the higher values being related to Cambrian rocks and the lower values to Ordovician and Permian rocks. The zone of positive anomalies extends south from Andersons Creek through Flowery Gully to Winkleigh and Glengarry. Although Permian rocks occur widely their thickness must be generally less than 300m. Some Ordovician rocks are also exposed but the size of the anomaly (+5 mgal average) in the Winkleigh-Glengarry region suggests a substantial presence of Cambrian rocks. It is not possible to estimate the thickness of Ordovician rocks locally but the Cambrian rocks must be at least 600 - 800m. thicker. The estimate depends on the density assumptions made and whether ultrabasic rocks are locally concentrated beneath the Glengarry region. The maximum thickness is about 3000m.

### 3. Tertiary basins regional survey

Source: Tasmanian Department of Mines

Reference: Longman and Leaman (1971)

Station spacing: 1.5 to 2 km.

This survey was directed at definition of Tertiary structures and deposits and these were comprehensively interpreted. It covers most of EL 6/81 north and west of Conara and south of Launceston. Small sections of the survey extended into regions of exposed Upper and Lower Palaeozoic rocks but only one such region was interpreted (Golden Valley to Deloraine). The Golden Valley-Deloraine section was located at the western margin of EL 6/81 and examined the +5 to +9 mgal anomaly related to the Cambrian rocks exposed at Quamby Brook. As the rocks have not been sampled for density analysis no reliable estimate of thickness is possible. However, using typical values for Cambrian rocks at Beaconsfield and Moina the minimum thickness is 2000m. Volcanics are included in the section. The 600 - 900m. estimate given by Longman and Leaman (op cit) has been revised using additional density data but none has been derived from this site.

Two major faults flank the base of the Great Western Tiers and different geology and gravity responses may be associated with them. A typical southwest-northeast traverse, near Bracknell for example, includes Middle to Lower Permian rocks - fault - dolerite intruded into Triassic rocks - fault - Tertiary basin. The exact nature of the first fault has never been established and it is at least Jurassic in age. The second fault displays largely Tertiary motion. The Tertiary sediments are at least 600m. thick (see interpretation Longman and Leaman, op. cit) and cover the bulk of EL 6/81 east of Cluan and Bracknell. A very strong gravity gradient is associated with the Tertiary fault but no clear gradient attaches to the older(?) structure. However, west of it where the Permian is relatively uplifted - and the basement with it - the gravity residual field is strongly positive,

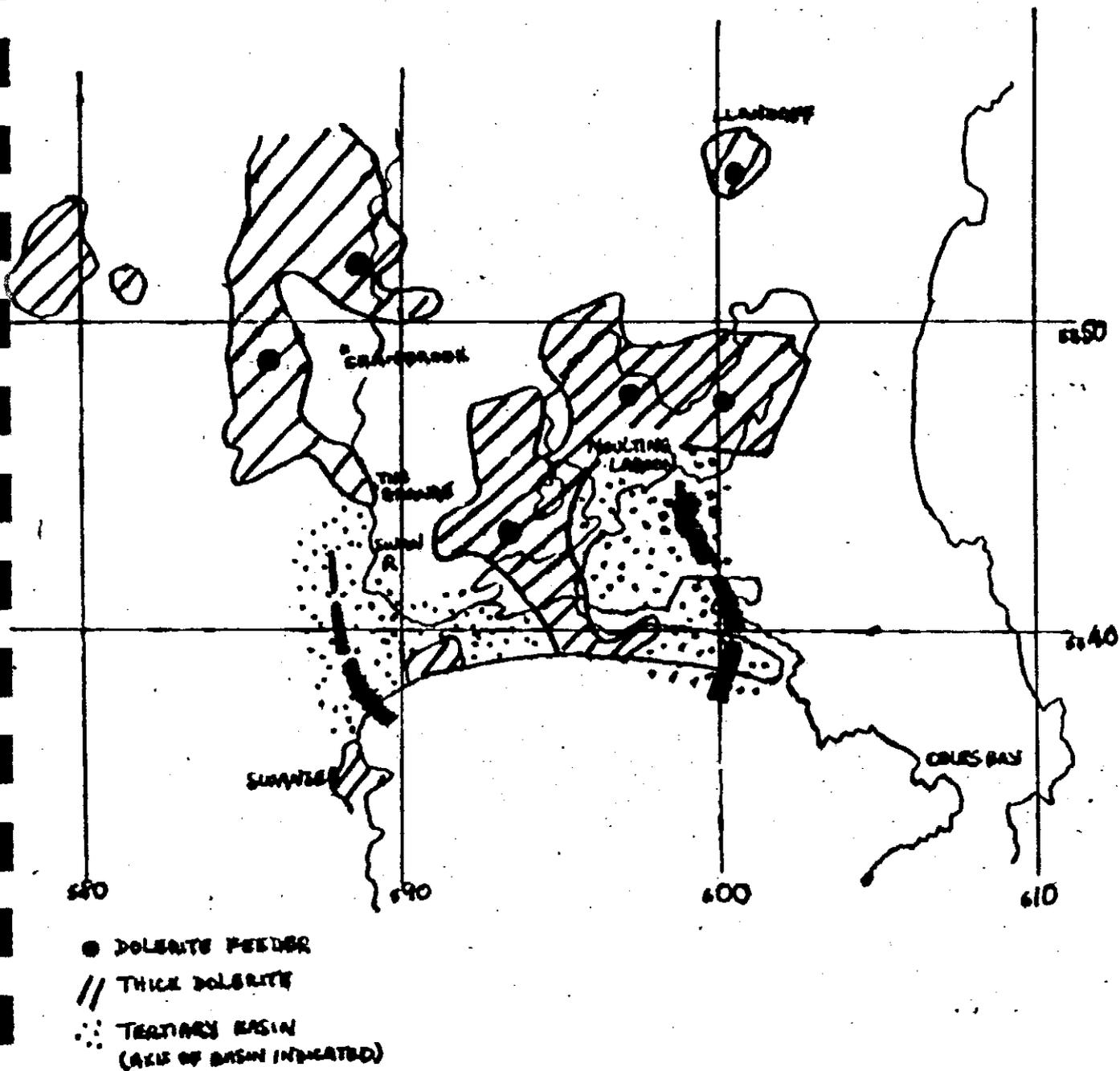


FIGURE 5

and Richardson since the latter figure was based on real density values and checked by reflection sounding. Street's estimate of up to 800m. is not supported. The anomalies do increase seaward and a greater thickness is likely offshore in Oyster Bay.

The survey also located some areas in which the dolerite intrusion has produced thick bodies with the exclusion of the Permian and Triassic rocks. These zones are shown hatched in Figure 5. Although there is little drillhole control of the scale of the Triassic coal-bearing section or Permian deposition the unhatched areas offer the best prospects. Tertiary sediments are present south of "The Grange" and south of Moulting Lagoon.

#### 5. Great Lake regional survey

Source: University of Tasmania Honours Project

Reference: Jones, Haigh and Green (1966)

Station spacing: variable, 1 - 2 km.

Comment: The interpretation is wholly restricted to an examination of the structure of the dolerite and basalt masses around Great Lake.

The survey falls entirely within E.L. 31/80.

The station density is quite uneven, but the large 18 mgal. anomaly centred on the northern half of Great Lake is clearly related to a substantial thickening in the dolerite sheet. A thickening of 1000 - 1100m. was deduced by the original authors and the estimate seems reasonable. It has been suggested that the basalt plain west of Miena is more than 100m. thick. It is not certain if this is so, but the contours of Bouguer anomaly suggest, by lack of association with the basalt exposures, that the dolerite sheet is locally thicker in this region - by 250 to 350m. Similar localised thickening of the sheet (150 to 200 m.) is evident between Shannon and Lake Echo and in the Arthurs Lakes area. The Tertiary basalts in the region do not produce any significant gravity effects.

CONCLUSIONS AND RECOMMENDATIONS

No attempt was made in the preceding section to interrelate the various fragments of information deducible from the existing surveys which are relevant to the current objectives. With few exceptions the available data is lacking in resolution and is unsuited to treatment of many of those objectives. However, it has been possible to glean much regional structural information and indicate the likely general composition of the pre-Permian basement rocks. Refinement of this information and more detailed specification of basement depth, likely thickness of Permo-Triassic cover and variation of dolerite thickness will depend on more detailed or more extensive surveys.

The review has shown that

1. Precambrian rocks are relatively restricted as the immediate basement in any of the licence areas. The regional gravity (helicopter coverage) and high altitude magnetic profiles support this conclusion and imply Lower Palaeozoic rocks as the general basement for most of E.L. 6/81 and at least part of E.L. 31/80. The deduced composition of the basement is shown in Figure 6. (PE= Precambrian, E= Cambrian, O= Ordovician, Sms = Silurian Mathinna Beds, Dg = Devonian granite).
2. The Lower Palaeozoic rocks are extremely varied - as reflected by the range of magnetic and gravity field properties observed when direct association of field and material is possible.  
Magnetic data, though sketchy, imply the presence of both Ordovician and Cambrian rocks in the Upper Midlands region from south of Cressy to west of Oatlands.
3. Basic and/or ultrabasic rocks are present within the basement complex, at an uncertain depth, immediately west of the major lineament extending south from Beaconsfield. The trend of such materials changes near Ross from NNW - SSE to N - S. It is presumed that these rocks are Cambrian in age (E?).
4. Similar rocks (as in 3) may also underlie the immediate vicinity of Great Lake - Lake Echo. However, the magnetic features recorded are also consistent with the extremely thick (1000m.) dolerite body at Great Lake and its possible southward extension. For this reason only Precambrian basement is shown in Figure 6.
5. Some areas can be identified in which the dolerite capping, or content, of a Permo-Triassic section is thickened. These are restricted to a portion of E.L. 16/81 (Figure 5) and around Great Lake (Figure 7). No other data is sufficiently detailed to be of use in respect of the coal, oil, shale objectives of E.L. 31/80 and E.L. 16/81.
6. Substantial parts of E.L. 6/81 contain post Carboniferous materials with thicknesses in excess of 400m. The only areas in which Lower Palaeozoic or Precambrian rocks occur within 300 - 400m. of the surface are near Glengarry and south of Deloraine along a south east trend from Quamby Brook to Little Billop at the base of the Great Western Tiers.

5 cm

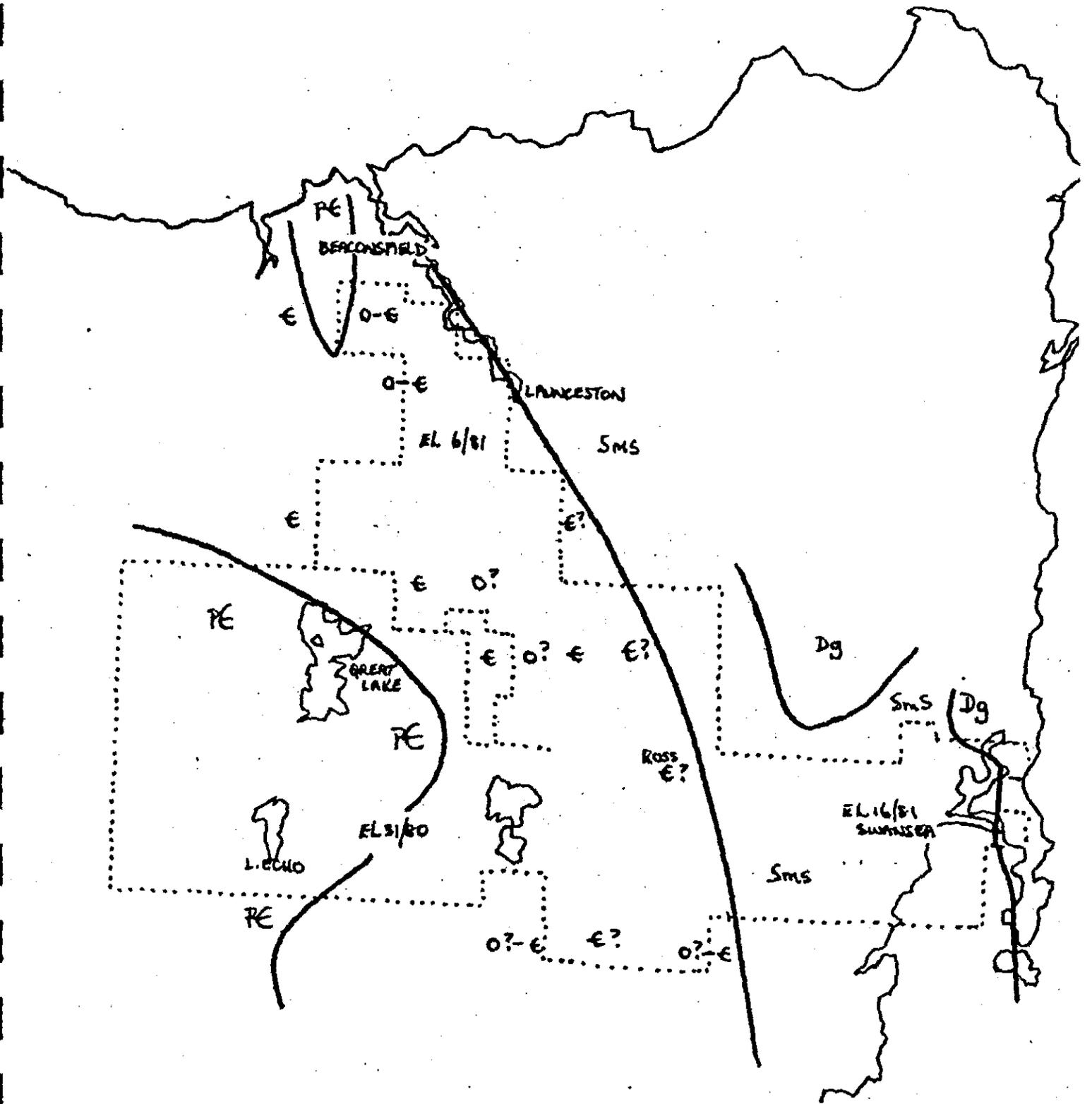


FIGURE 6  
POSSIBLE COMPOSITION OF PRE-PERMIAN  
BASEMENT

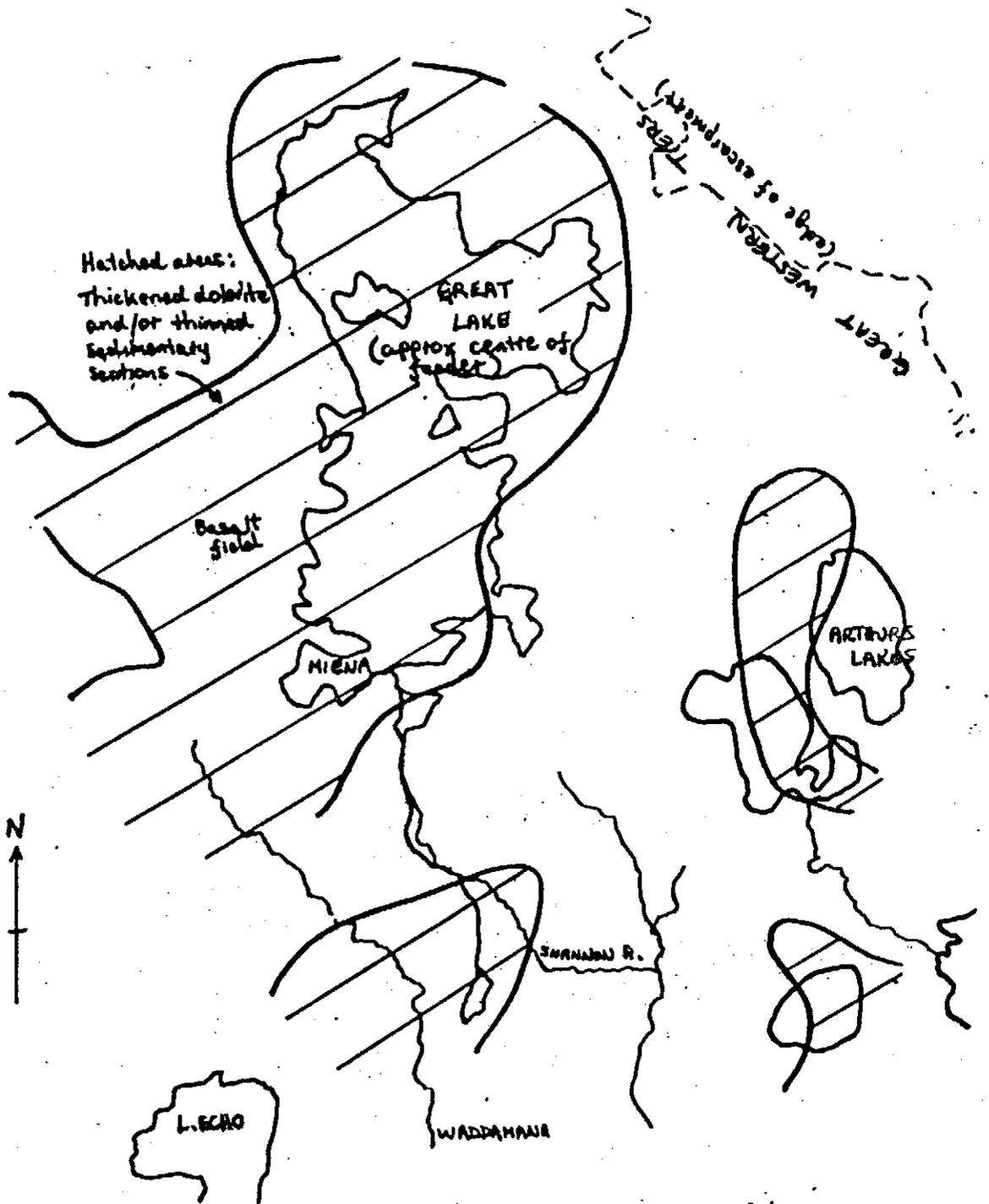


FIGURE 7

DOLERITE THICKNESS VARIATIONS  
GREAT LAKE REGION

5 cm

7. The general form and thickness of Permian deposition can not be deduced from the existing data.
8. With few localised exceptions, where gravity data is available at 1 - 2 km. spacings, it is not possible to reliably estimate the general thickness of post Carboniferous materials. As much of E.L. 6/81 is adequately covered it is possible to state that these materials amount to 600 - 1200m. depending on the presence of local faulting, dolerite sheets and Tertiary sediment. It is not possible, even in these regions, to accurately specify variations in thickness of Permian and Triassic rocks. Only an estimate of their combined thickness is possible.  
For most of E.L. 31/80 and a part of E.L. 6/81 no reliable estimate of 'cover' thickness is possible. The very regional surveys, however, do suggest a maximum thickness of 1 - 2 km.
9. No data is available which can assist in method appraisal for assessment of sedimentary mineral concentrations.

#### REGIONAL OBJECTIVES

E.L. 6/81 Definition of Lower Palaeozoic basement with likely depth from surface of less than 300 - 400m.

The review indicates that this condition is only likely to be met within the following 10 km. grid squares (SW corner stated). (see Figure 8)

- A:1. 480000 mE, 5420000mN: Glengarry - Frankford
2. 490000 mE, 5420000mN (west half): Exeter West
3. those portions of  
470000 mE, 5420000 mN and 480000 mE, 5430000 mN  
within E.L. 6/81.

It is recommended that this region (A) be covered by an aeromagnetic survey in order to better define basement form and identify clearly the position and continuity of the Cambrian rocks within it. The extant gravity coverage is adequate to allow an integrated interpretation.

The line spacing in this relatively small area should not exceed 500m. and since dolerite is generally absent the sensor clearance could be reduced to 150 or 200 m. Estimated line km:400.

- B:1. those portions of  
470000 mE, 5390000 mN (south half): Golden Valley  
470000 mE, 5380000 mN (north half)  
within E.L. 6/81.
2. 480000 mE, 5390000 mN (SW of NW-SE diagonal)
3. 480000 mE, 5380000 mN (north half)
4. 490000 mE, 5370000 mN
5. 490000 mE, 5380000 mN (SW of NW-SE diagonal)
6. 510000 mE, 5350000 mN (possible).

It is recommended that this region be covered by an aeromagnetic survey and a gravity survey in order to define the actual content and continuity of the basement rocks near the foot of the Western Tiers - in particular the extent of Cambrian volcanics.

857040

1:250 000

5 cm

WINKLEIGH

GLEGANBY

5430

AREA A

Magnetics:  
height. 200m  
line spacing. 500m

5420

LAUNCESTON

5410

DELORWHE

5400

QUAMBY BROOK

CLANN

5390

COVER EXCEEDS 400m

BRACKNELL

CESSY

5380

WESTERN LAAGOON

AREA B

Magnetics:  
height - 200m  
line spacing. 1km, 500m prof

Gravity:  
area needing coverage shown

Spacing. 1.5 - 2 Km

5370

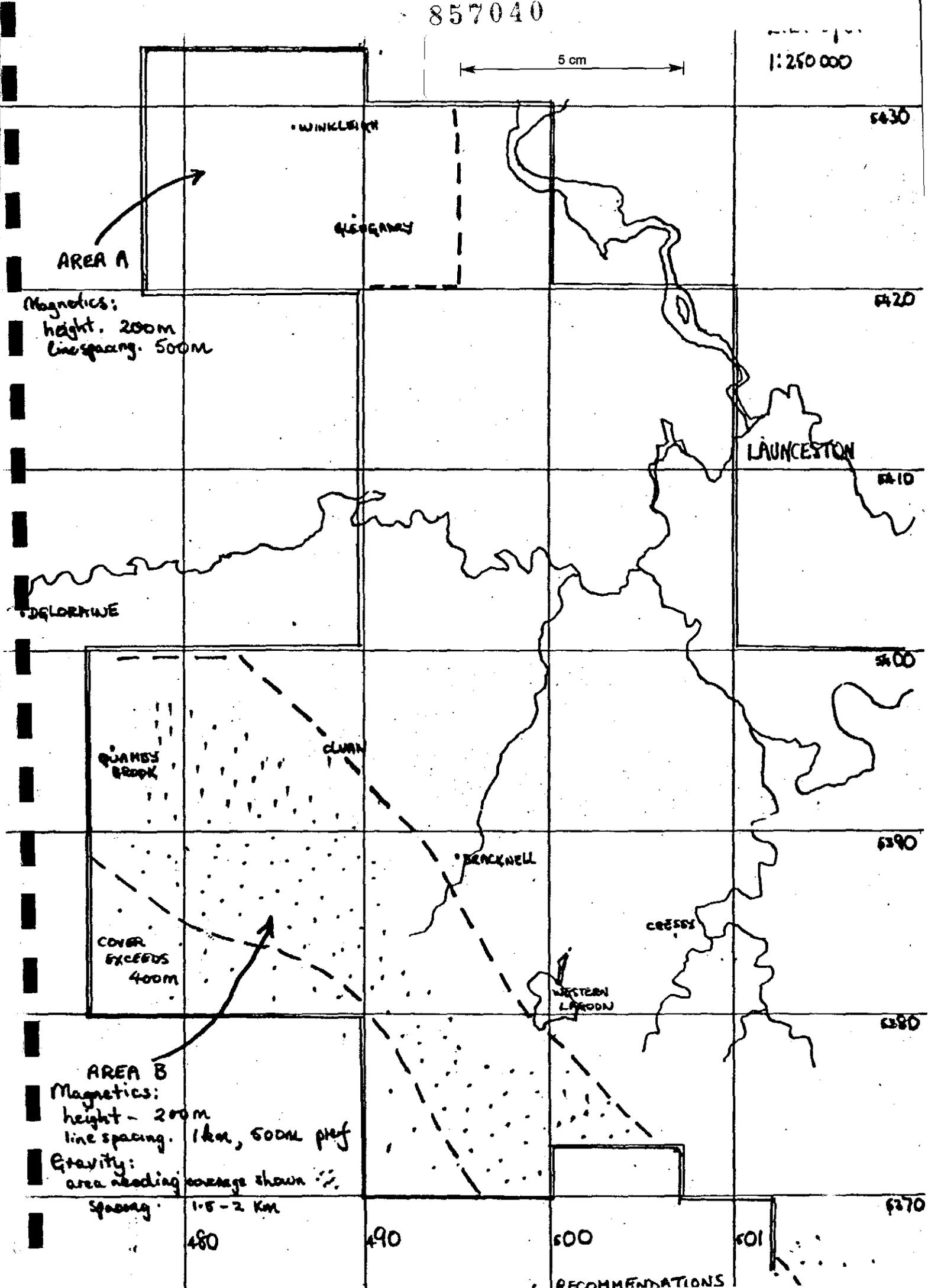
480

490

500

501

RECOMMENDATIONS



2. Cover the area with a detailed gravity survey to specifications similar to those given in Appendix 1 (p. 1-3). This will allow evaluation of overall structure, location of faults with throws in excess of 50m. and absolutely define any dolerite complications. The survey must extend about one kilometre onto controlled information, or coal measures, on either side of the examined dolerite mass.

Such a survey would describe the overall form and distribution of the materials and drilling of selected sites may then establish the presence of workable seams. Such scout, but guided drilling, can then be followed by expanded programmes - if initial indications warrant.

In the areas of exposed coal measures a different approach is required. The problems then relate to seam disruption and continuity rather than the more basic questions of presence of seams or even of the coal measures themselves. Only two methods are workable in this situation - resistivity and seismic reflection. Experience at Seymour (Richardson and Leaman, 1980) suggests that the latter is likely to be most effective and able to detect quite small disruptions. Suggested specifications are given in Appendix 1 (p. 1-3). Resistivity is a cheaper and easier approach but, until rock property contrasts are established and the method tested, it must be considered much less reliable. As electric logs have been obtained for many holes, a practice which should be continued, review may suggest whether resistivity is applicable. The writer considers that this should be possible in 2-3 months time when an adequate and widespread collection of logs will be available.

The detailed effort suggested for the Woodbury region may be considered typical of second phase exploration - where a target area has been identified by reconnaissance geophysics or other means.

Review submitted on behalf of  
Leaman Geophysics  
by



Dr. D. E. Leaman B.Sc. Ph.D

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APPENDIX ONECOMMENTS ON SURVEY SPECIFICATION

Various styles of survey and specification have been contrasted in this review. The coarse regional surveys with line or station spacings of 7 - 16 km. have been able to suggest gross structural features which are relevant to the all minerals licence (E.L. 6/81). Review of the other, rather patchy data, shows that line or station spacings of no more than 2 km. are necessary to provide information on dolerite thickness variations, dolerite distribution, moderate scale structures and thickness of Permo-Triassic rocks. Gravity surveys are established as the most reliable means of achieving these objectives although it is apparent that appropriately specified magnetic surveys can yield much information. Magnetic interpretation of section thicknesses must, however, be more uncertain due to the assumptions which may be made about the properties of the magnetic basement.

Specifications must also be tailored to meet any specific objectives and for this reason two sets of guide specifications have been included - one for rapid area assessment and the second for detailed needs.

Assessment surveys

Only the gravity or magnetic methods are viable at this stage in the areas covered by E.L. 31/80, 6/81, 16/81.

Gravity: - Station spacing : not to exceed 2 to 2.5 km.  
(1 - 1.5 km. preferred).

- Observations to be drift and loop adjusted.
- Elevations to be determined within 1 - 2 m. (barometric methods are suggested including drift, loop adjustments using Lands Department survey point control with short - in terms of distance and time - intervals between control points and observation points. No unsupported dependence on a base barometer should be accepted.)
- reductions should be made using a Bouguer density of  $2.67 \text{ t/m}^3$  and all stations must be terrain corrected. The radius of correction for most areas will be 15-21 km.
- the results are to be plotted with 1 mgal contour interval and subjected to a range of filters. The first filter applied should have an aperture of twice the station spacing. (filtering to produce regionals and residuals is a basic step towards identification of anomaly sources and their likely depth. It should be noted that a 2 km. station spacing may not allow resolution of features within 300 - 500 m. of the surface but will identify the areal extent of most anomalous structures. Filtering also leads to loss of data and adequate data peripheral to the target area must also be acquired.
- modelling and extended processing requirements to be appraised after inspection of the filtered data.

Gravity surveys to the above specification could be relatively rapid since access (at 2 km. approx. spacing) is reasonable in all licence areas. However, an average of no more than 16 stations per day should be expected (64 km.<sup>2</sup>).

Surveys with these specifications could be expected to indicate gross variations in dolerite or sedimentary section

- Magnetics:
- line spacing: not to exceed 2 km.
  - sensor height (above ground): nominally 300m.  
(these parameters are a compromise between reasonable coverage, definition of anomaly dimension and extent, and detail. Lower ground clearance in dolerite areas would require excessive filtering, yet enough dolerite 'character' must be observed in order to resolve dolerite variations).
  - clearance is to be determined by radar altimetry and the results processed by upward and downward continuation to a 300 m. equivalent clearance.  
(this processing overcomes any problems of maintaining precise clearances during the survey - especially when the terrain is difficult. The sensor should, however, be maintained in a flight envelope of say 250 - 400m., in order not to lose data resolution, (the desired nominal clearance is 300m.)

A complete specification is set out in Appendix 2. A survey with the above specification could, depending on basement properties, yield data comparable with a gravity survey.

- prior to interpretation of the survey at least 200 sites should be visited in the survey area and field determinations made of rock susceptibility and N.R.M. All rock types should be included. Where some units are not exposed locally 50 sites within the nearest known exposures should be sampled.

#### Seismic reflection:

- reflection methods could be considered for assessment of some profiles across the Tasmania basin. They are likely to be the only means of defining most aspects of the units within, and overall forms of, the Permo-Triassic succession. Traversing is likely to be very expensive and should be selectively employed - after application of the other methods.
- typical specifications might be:
  - Shot depth: 10 - 15m.
  - Shot size: 10 kg. (subject to testing).
  - Geophone spacing: 100m.
  - Offset: 250m. (subject to testing)
  - Fold: 3 to 6.
- It may be possible to achieve useful data with single fold recording and longer spacings but inadequate experience of central Tasmania conditions must mean that any major programme of reflection exploration will be an expensive research effort initially.

#### Detailed Surveys

Detailed surveys could conceivably include gravity, magnetic, seismic reflection, logging and possibly resistivity methods in coal exploration areas and gravity, magnetic, electro-magnetic, 1P and resistivity methods in the all minerals area. No specification is suggested for placer evaluations pending some further data on mineralogy and associations. In addition no specification of 1P or resistivity methods is provided since their application is not justified before other, reconnaissance, methods indicate targets. Other 'methods' is taken here to include geochemical methods.

- Gravity: - for the resolution of faulting at a scale of 50-50m. or greater and detailed variations in dolerite intrusions. The station spacing should not exceed 300m. and every effort must be made to ensure elevation errors do not exceed 1m. Coarse levelling is to be preferred. Use of pressure tubes is one method of sustaining survey speed and elevation accuracy. All other specifications apply (refer p. 1. 7)
- Magnetics: - for the resolution of talus, boundary mapping, etc., ground surveys with observation interval of 5m. and, in dolerite areas, use of fluxgate magnetometer.  
- for the resolution and tracing of moderate scale targets; line spacing - 250m., clearance - 100 to 150m. The target should be shown either by ground or reconnaissance work, to possess a magnetic signature.
- Reflection: - for location of small faults, coal seam continuity (especially where there is no surface dolerite).  
- shot offset, geophone spacing : 10-15 m.  
- shot depth: 3 - 5 m.  
- shot size: 100g.  
- geophones: 28+Hz.  
- coverage: 4+ fold.  
- digital recording, non Mini-Sosie techniques.
- Electromagnetics: - this technique is not recommended at the current stage of exploration in E.L. 6/81 since too little is known about the target rocks and the depth of burial - a key factor in specification of EM surveys - is still to be defined by other methods.
- Radiometrics:- detailed ground or airborne radiometric methods could be applied to the placer problem if it can be shown that such deposits exist and bear a suitable mineralogy. The inverse approach of random test surveys is likely to be untenable, simply because the concentrations, though many may be of small volume and therefore will only be detected by very detailed surveys or critically chosen parameters.
- Down-hole logging:  
- logging should be undertaken as a matter of course with three objectives.  
a) to collect rock property data which will aid in interpretation or suggest other practicable methods,  
b) to allow potential correlation of units,  
c) to check recovery and estimate in situ characteristics of material. In the case of coal exploration some analytical work may be saved.

APPENDIX TWOSPECIFICATION OF MAGNETIC SURVEYS

1. Description of survey area with indication of boundaries, including 1 : 50000 topographic maps to assist in quoting. Prescribe fixed wing aircraft.
2. Flight specification:
  - a) lines to be flown in an east-west direction.
  - b) lines to be \_\_\_\_\_ apart.
  - c) after recovery line position must deviate less than 20% from the specified position over 90% of the total line length.
  - d) in-fill lines to be flown at the operator's expense wherever line spacing exceeds specification by 50% for more than 10% of line length and are to cross two tie lines.
  - e) tie lines are to be flown normal to the traverse lines and have a spacing of (say 7.5 - 10 km. for small surveys, 40 - 50 km. for large).
  - f) terrain clearance to be recorded within  $\pm$  10m. in the band using a radar altimeter.
3. Navigation and flight path recovery specification:
  - a) all data to be collected in digital and analog format.
  - b) a visual record for flight path recovery must be obtained whether it is the sole or part means of navigation.
  - c) the maximum distance between recovered points on each line will not exceed 1.5 km.
  - d) the resultant plan will be presented in the form of a navigation photo mosaic, line transparency and line dyeline plan at 1:50000. Plans should show photo centres recovered, control points, AMG and observation points if a Doppler system is used.
4. Geophysical data specification:
  - a) Magnetic data will be recorded with a precision of 1 nT or 50m. or better.
  - b) Up to 2nT peak to peak noise levels will be considered tolerable.
  - c) the maximum acceptable error will be 4nT after correction for diurnal variation with a reproducibility of better than 4nT over 5 km. at an altitude of 500m. morning and afternoon of eachday. The test to be recorded.
  - d) magnetic base variations shall be observed and recorded.
  - e) all data to be collected in digital and analog format.
  - f) analog chart scales should maintain highest sensitivity but, in addition, a record of the magnetic observations shall be made which maintains a single scale setting throughout.
  - g) records will not be accepted where magnetic field variations at the base station exceed 5nT in 5 minutes (non linear).
5. Digital record specification:
  - a) tape supplied to be 9 track, 800BPI, NRZI, EBCDIC.
  - b) records of navigation, magnetic and altitude data are to be provided.
  - c) each tape is to be fully labelled as to flight line, content, date and evaluation code for reference.
  - d) the evaluation code will prescribe the internal formatting of the recorded data.

- e) a tabulation listing instrument settings, scales and calibrations is to be provided with the record set.
  - f) details of all instrumentation specifications are to be provided.
6. Calibration specification:
- a) magnetometer and altimeter tests and calibrations will be made at least twice per day.
  - b) heading errors will be corrected to  $\pm 1\text{nT}$  prior to acquisition of data or acceptability of heading corrections established.
  - c) the twice daily test may be made on any convenient alignment but records must be assembled and supplied at the end of field work.
7. Contour plan specification:
- a) all plans to be produced at a scale of 1:
  - b) plans are to be prepared with contour intervals of 5nT (accentuated 50nT) or 10/100 nT as determined by the data except in areas of steep gradient where a reasonable contour density may be used.
  - c) all plans are to be supplied as transparencies and prints.
  - d) all plans are to be supplied with recovered flight path and control identification.
  - e) all plans are to show the AMG grid.
8. Processing sequence:
- a) Residuation of raw data with respect to the International Geomagnetic Reference Field.
  - b) Upward and/or downward continuation of the residual data to yield the effective terrain clearance required  
  
(assumption of a uniform vertical gradient over the survey area will not be accepted).
  - c) Contour map preparation of
    - i) the uncorrected residual data
    - ii) the continued residual data
9. All data derived from the survey will be the absolute property of \_\_\_\_\_ and will be delivered to \_\_\_\_\_ at the completion of the programme. The data includes, but is not limited to, analog and digital records, tracking film, etc.
10. Summary:
- a) E.W. lines, spacing ..... (Clause 2)
  - b) nominal terrain clearance ..... (Clause 8b)
  - c) clearance variation,  $\pm$  ... m, .... (Clause 2f)
  - d) data presentation as residual and as continued residual at clearance required at (b).
  - e) presentation of all analog and digitally recorded data, including radar altimetry.
  - f) line recovery and preparation of flight path plot.

Tenderers should state:

1. Mobilisation fee, if any.
2. Magnetic data acquisition costs per line km.
3. Aircraft type.
4. Cost of line recovery and flight path plots.
5. Cost of processing, correction and reduction to the clearance proposed.

6. Cost of presentation of the data as residual and continued field as contour maps at the scale proposed.
7. Cost of preparation of any photomosaic or other flight reference materials.
8. Aircraft availability and payment schedule.
9. Clear acknowledgment of acceptance of specifications.
10. Cost of presentation of stacked profiles, either of the observed or continued data.
11. Cost of presentation of the data in the form of computed vertical gradient as contour maps at the scale proposed.
12. Cost of preparation of a contour map of the data continued to a terrain clearance three times that stated in 7(b).

The specification form may be completed as required. The following details are suggested for the particular recommendations.

Item 1. Insert a complete description of the area. A set of air photos will also be required by the contractor chosen.

Item 2. b)     500 m.           E.L. 6/81 area A  
               500/1000 m.       6/81 area B  
               1000 m.           6/81 area C  
               2 km.             31/80, 16/81

(If Victor is successful in its application for a North Tasmania oil licence then 2 -3 km. is suggested for that area and E.L. 31/80 and the detailed pieces could be superposed or omitted, especially areas B, C)

2. f)     50 - 250 m.     E.L. 6/81 area A  
           100 - 300 m.       area B  
           250 - 400 m.       area C and E.L. 31/80, 16/81

(again, if the area is expanded and oil/basement exploration is the goal then the entire area should be covered at 400 - 600 m. clearance (nominal 500 m., item 7 b)).

Item 7. a) scale. suggest 1:50000

b)     200 m.           E.L. 6/81 areas A, B  
        300 m.           E.L. 6/81 area C, 31/80, 16/81

(500 m. if area expanded with oil goal)

Item 8. add (d). Preparation of stacked profiles of continued data and two sample lines of uncorrected data.

Item 9. Include company name and city of registration.

Item 10. Insert details from 2b, 2f, 7b.

NOTE: Pending review of the observed data and data after initial correction it might be necessary to continue processing to the forms listed under items 11 and 12 of 'Tenderers should state'. These presentations of the field may be required for complete resolution of the wide range of target structures under examination.

Stacked profiles (the added clause 8d) should be ordered as part of the original request as these will provide a basis for quantitative interpretation and indicate whether items 11, 12 are needed.

APPENDIX THREEPOSSIBLE CONTRACTORS

Gravity: Required only for data collection and possibly basic reduction.

Geophysical Service Inc.

9 Eyfield St. N. Ryde, NSW (02)8871122

Austral Exploration Services

5 Deloraine Rd., Edwardstown, SA (08)2761233

Geoquest Pty Ltd

Suite 107, 55 Falcon St., Crows Nest, NSW (02)9293388

Layton Geophysical International

6/20 Blamey Ave., Campbell, ACT (062)470753

Unisearch Ltd

Uni of NSW, Kensington NSW (R. Whiteley) (02)6623133

Solo Geophysics

3A McInnes St., Ridlyton, SA (08)468099

Magnetics: Do not consider helicopter surveys. They are nearly three times as expensive as fixed wing and clause 2f overcomes the need for them anyway.

Austirex Aerial Surveys

27 Merriwa St., Gordon, NSW (02)4984566

Geoex Pty Ltd

50 Mary St., Unley, SA (08)2725211

Geoterrex Pty Ltd

13 Whiting St., Artarmon, NSW (02)4383866

Hunting Pty Ltd

Centrecourt, 1 Pirie St., Fyshwick ACT (062)804277

Scintrex Pty Ltd

6 Tramore Pl., Killarney Heights, NSW (02)4515367

Unisearch Ltd

see above.

Warning: ensure that the contractor guarantees to fulfil clause 8 by using proper continuation methods.

Possible costs: airborne magnetics. \$10-15 per line km. (incl processing.  
gravity. \$8-12 (\$20+) per station for small areas (large areas) incl. basic reduction.  
No contractor is known to the writer who will willingly calculate terrain corrections for Tasmania.  
(Leaman Geophysics: \$3 per station full correction)

The above estimates exclude mobilisation costs, general expenses and any interpretation costs. The latter is purely dependent on the data, objectives and the kinds of processing required.

DENSITY MEASUREMENTS OF THE MAIN ROCK TYPES IN THE WOODBURY AREAT.G. SummonsINTRODUCTION

Density determinations on the common rock types at Woodbury (sandstone, mudstone and dolerite) were required for two reasons:-

- (i) To provide information on bulk densities for contract mining engineers, and;
- (ii) To provide data for geophysicist, Dr. D.E. Leaman, so that he could 'calibrate' the local rock types as part of the Woodbury area gravity survey.

METHODS OF DENSITY MEASUREMENT

The Department of Mines, Launceston Laboratory, conducted the measurements on 25 samples of sandstone, mudstone and dolerite, obtained from HQ wireline core from the Woodbury area. All samples were taken from below the base of oxidation.

A. IN SITU DRY DENSITY

HQ core samples of average length 150mm had volume calculations made from five length and two diameter measurements. Significantly, the average diameters of the sandstone and mudstone cores was 61.6mm compared to the nominal diameter for HQ core of 63.5mm, thus indicating attrition of the core during drilling. Measurement of sample mass then enabled the calculation of the insitu dry density.

B. BROKEN (BULK) DRY DENSITY

The core samples were crushed to -15mm, and the volume of broken sample estimated using a glass measuring cylinder, with consequent calculation of the bulk dry density.

C. BROKEN (BULK) WET DENSITY

The crushed core samples were then immersed in water for seven days and recovered by filtration and weighing of the filter residue; the results were expressed in terms of retained water as a percentage of the original mass.

Further details on the procedure are shown in the Appendix.

INTERPRETATION OF THE RESULTS

The results of the density measurements are shown in Columns 1, 5 and 7 in Tables 1, 2 and 3.

The wet density data was obtained as follows:-

Insitu dry density  $D1 = \frac{M1}{V1}$

Broken dry density  $D2 = \frac{M1}{V2}$

And broken wet density  $D3 = \frac{M2}{V3} \approx \frac{M2}{V2}$

- Where  $M1$  = Insitu dry mass of sample
- $M2$  = Broken wet mass of sample
- $V1$  = Insitu dry volume of sample
- $V2$  = Broken dry volume of sample
- $V3$  = Broken wet volume of sample

Volume  $V3$  was assumed to be the same as Volume  $V2$ . Thus, for an increase in original mass ( $M$ ), of  $x\%$  water, the wet mass,  $M2 = M1 + xM1$

And  $D3 = M1 \frac{(1 + x)}{V2}$

i.e.  $D3 = (1 + x) D2$

Accordingly, the insitu wet density ( $D4$ ) was taken as approximately  $(1 + x) D1$ .

COMMENTS & CONCLUSIONS

A. DENSITIES

1. Sandstone

- (a) In situ dry density of 2.25 T/m<sup>3</sup>
- (b) In situ wet density of approx. 2.51 T/m<sup>3</sup>
- (c) Broken dry density of 1.28 T/m<sup>3</sup>
- (d) Broken wet density of approx. 1.43 T/m<sup>3</sup>

2. Mudstone

- (a) Insitu dry density of 2.36 T/m<sup>3</sup>
- (b) Insitu wet density of approx. 2.65 T/m<sup>3</sup>
- (c) Broken dry density of 1.27 T/m<sup>3</sup>
- (d) Broken wet density of approx. 1.43 T/m<sup>3</sup>

3. Dolerite

- (a) In situ dry density of 2.80 T/m<sup>3</sup>
- (b) In situ wet density of approx. 2.90 T/m<sup>3</sup>
- (c) Broken dry density of 1.48 T/m<sup>3</sup>
- (d) Broken wet density of approx. 1.54 T/m<sup>3</sup>

The wet density figures are probably inflated, as discussed subsequently in point C.

B. BULKING FACTORS

Bulking factors were then calculated by taking the reciprocal of the ratio of the broken dry to in situ dry measurements (Tables 1, 2, 3).

- (i) Sandstone = 1.75, i.e. a 75% volume expansion after excavation
- (ii) Mudstone = 1.86, i.e. an 86% " " " "
- (iii) Dolerite = 1.89, i.e. an 89% " " " "

The results for sandstone and mudstone appear realistic when compared to the data on bulking factors quoted by Berkman (1976), namely, 75% and 85% volume expansion for sandstone and slate; the fissile nature of the mudstone is regarded as approximately the behaviour of crushed slate.

However, the post excavation increase in volume for basalt is reported as 75% (Berkman, 1976), and the 89% volume expansion obtained for Woodbury dolerite probably requires actual excavation to enable confirmation of this figure to be made.

C. ABSORBED WATER

The apparent absorbed water in the samples is as follows:-

- (i) Sandstone = 11.9%
- (ii) Mudstone = 12.2%
- (iii) Dolerite = 3.5%

However, it should be noted that the laboratory scale modelling of actual excavation conditions has several deficiencies; e.g. the ratio of the size of the crushed sample fragments to the original core sample, cannot be regarded as the same as the ratio of the size of the explosive-fragmented rock to the in situ volume of rock in the field. The latter volume is influenced by the spacing and orientation of discontinuities (bedding planes, joints etc.).

D.E. Leaman (pers. comment) has obtained in situ wet density measurements of approximately 2.40 and 2.42 T/m<sup>3</sup> for sandstone and mudstone respectively.

The samples used by Leaman were considerably larger than 15mm, and may be regarded as more reliable indicators of actual in situ absorbed water values.

Application of the Leaman data to the in situ dry density measurements suggests that the absorbed water is of the order of 7% and 2.5% for sandstone and mudstone respectively.

Consequently, it would appear that the wet density values shown in Tables 1 and 2 reflect nearly total saturation of the samples, but not the anticipated in situ field conditions of absorbed water. In addition, significant amounts of free water was retained by the slime produced after crushing of the mudstone samples.

D. LITHOLOGICAL VARIATION

- (i) Sandstone: No significant variation between samples
- (ii) Mudstone:
  - (a) An interval of carbonaceous mudstone in hole W41 (samples 39, 40, 42), average  $2.44 \text{ T/m}^3$  in situ dry density; this is notably higher than the average value of  $2.36 \text{ T/m}^3$ .
  - (b) Samples 46-50 inclusive are from the tuff-siltstone sequence, and with an average of  $2.29 \text{ T/m}^3$  are notably lower than the overall in situ dry density average of  $2.36 \text{ T/m}^3$ .
- (iii) Dolerite:
  - (a) Samples 51, 52 and 73 possibly indicate more dense drilled margins of dolerite.
  - (b) Samples 52-57 inclusive are from a narrow dolerite sill from 60.09 - 67.68m in drill hole W41.

Reference:

Berkman, D.A., 1976. Field Geologists Manual. Mon. 9  
The Australasian Institute of Mining and Metallurgy.

TABLE 1:

SANDSTONE DENSITIES

Sample	Rock Type	Hole	Depth (m)	Density(T/m <sup>3</sup> ) Bulk			
				In Situ Dry (D1)	Wet (D4)	Dry (D2)	Wet (D3)
1	Lithic arenite, grey/green	W32	12.60	2.31	2.75	1.32	1.57
2	" "	"	20.80	2.28	2.66	1.45	1.69
3	" "	"	28.70	2.27	2.43	1.29	1.38
4	" "	W39	32.00	2.32	2.54	1.28	1.40
5	" "	"	37.00	2.30	2.52	1.32	1.45
6	" "	"	40.00	2.29	2.47	1.25	1.35
7	" "	W46	34.30	2.18	2.44	1.28	1.43
8	" "	"	43.40	2.24	2.55	1.21	1.38
9	" "	"	51.70	2.27	2.47	1.27	1.38
10	" "	W48	12.90	2.07	2.25	1.33	1.44
11	" "	"	20.80	2.20	2.50	1.23	1.40
12	" "	"	30.80	2.28	2.45	1.23	1.32
13	" "	W49	15.40	2.08	2.37	1.22	1.39
14	" "	"	19.10	2.17	2.55	1.24	1.46
15	" "	"	24.70	2.16	2.49	1.24	1.43
16	" "	W41	15.80	2.32	2.66	1.37	1.57
17	" "	"	28.40	2.37	2.55	1.29	1.39
18	" " , glauconitic	"	33.50	2.36	2.57	1.24	1.35
19	" " , grey/green	"	40.75	2.30	2.50	1.29	1.40
20	" "	W61	14.50	2.15	2.39	1.25	1.39
21	" "	"	17.70	2.15	2.44	1.32	1.50
22	" "	"	23.90	2.24	2.49	1.32	1.47
23	" "	"	28.60	2.32	2.72	1.25	1.46
24	" "	"	34.60	2.32	2.63	1.28	1.45
25	" "	"	40.60	2.20	2.46	1.25	1.40
AVERAGES:				2.246	2.514	1.281	1.434

TABLE 2:

MUDSTONE DENSITIES

Sample	Rock Type	Hole	Depth (m)	Density (T/m <sup>3</sup> )			
				In Situ		Bulk	
				Dry (D1)	Wet (D4)	Dry(D2)	Wet (D3)
26	Mudstone, silty, grey/brown	W32	52.70	2.39	2.83	1.29	1.53
27	" " "	"	53.20	2.37	2.70	1.27	1.45
28	Mudstone, grey/brown	"	54.40	2.39	2.59	1.26	1.36
29	" " "	W46	74.45	2.36	2.66	1.26	1.42
30	Siltstone/mudstone, grey	"	94.85	2.35	2.65	1.26	1.42
31	Mudstone, silty, grey/brown	W48	86.00	2.40	2.76	1.28	1.47
32	Mudstone, grey	"	89.20	2.30	2.82	1.21	1.48
33	" " "	"	89.90	2.35	2.59	1.24	1.37
34	Mudstone, carbonaceous	W41	21.80	2.34	2.61	1.27	1.42
35	" " "	"	22.00	2.32	2.55	1.27	1.40
36	Mudstone, grey	"	24.20	2.34	2.59	1.27	1.41
37	Siltstone, grey/brown	"	46.50	2.39	2.58	1.28	1.38
38	Mudstone, grey	"	47.50	2.39	2.61	1.35	1.47
39	Mudstone, carbonaceous	"	53.30	2.44	2.65	1.29	1.40
40	Mudstone, carbonaceous	"	54.00	2.42	2.66	1.40	1.54
41	Mudstone, grey, banded	"	55.00	2.43	2.62	1.31	1.41
42	Mudstone, carbonaceous	"	58.10	2.45	2.72	1.34	1.49
43	Mudstone, grey	W61	70.60	2.34	2.62	1.25	1.40
44	" " "	"	72.90	2.40	2.69	1.38	1.55
45	" " "	"	73.40	2.40	2.74	1.24	1.41
46	Mudstone, green/khaki	"	80.00	2.35	2.70	1.21	1.39
47	" " "	"	80.30	2.37	2.62	1.24	1.37
48	Mudstone, grey/green	W31A	53.20	2.30	2.60	1.18	1.33
49	Mudstone, cream/green	W36A	78.10	2.21	2.48	1.24	1.39
50	" " "	W67	81.80	2.24	2.60	1.20	1.39
AVERAGES:				2.362	2.650	1.272	1.426

TABLE 3:

DOLERITE DENSITIES

Sample	Rock Type	Hole	Depth (m)	Density (T/m <sup>3</sup> )			
				In Situ Dry(D1)	Wet(D4)	Bulk Dry(D2)	Wet(D3)
51	Dolerite, 1m below contact	W36A	82.20	2.94	3.09	1.40	1.47
52	Dolerite, 2.2m " "	W41	62.30	2.95	3.10	1.48	1.55
53	Dolerite	"	62.90	2.90	2.97	1.55	1.59
54	"	"	63.70	2.93	3.06	1.57	1.64
55	"	"	65.10	2.81	2.93	1.49	1.55
56	"	"	66.80	2.89	2.96	1.49	1.53
57	Dolerite, 0.3m above contact	"	67.40	2.55	2.66	1.38	1.44
58	Dolerite	W50	44.00	2.78	2.85	1.50	1.54
59	"	"	45.00	2.77	2.88	1.49	1.55
60	"	"	46.00	2.79	2.89	1.61	1.67
61	"	"	47.00	2.79	2.95	1.47	1.56
62	"	"	48.90	2.72	2.79	1.44	1.48
63	"	"	49.80	2.75	2.81	1.39	1.42
64	"	"	50.80	2.76	2.86	1.40	1.45
65	"	"	51.80	2.84	2.92	1.48	1.52
66	"	"	52.80	2.75	2.80	1.51	1.54
67	"	"	53.70	2.79	2.89	1.46	1.51
68	"	"	54.70	2.74	2.82	1.47	1.51
69	"	"	55.60	2.79	2.89	1.42	1.47
70	"	"	57.60	2.76	2.88	1.47	1.54
71	"	"	60.60	2.73	2.84	1.48	1.54
72	"	"	63.60	2.76	2.84	1.40	1.44
73	Dolerite, 0.6m below contact	W63	43.50	2.84	2.93	1.59	1.64
74	Dolerite	W68	29.20	2.83	2.91	1.50	1.54
75	"	"	31.40	2.82	2.91	1.65	1.70
AVERAGES:				2.799	2.897	1.484	1.536

## DEPARTMENT OF MINES—TASMANIA

857058



LAUNCESTON OFFICES  
287 WELLINGTON STREET  
SOUTH LAUNCESTON 7250

TELEPHONES:  
Metallurgical Research .. .. } 44 2431-2  
Laboratory .. .. } (2 lines)  
Mines Inspection .. .. }  
Explosives & Inflammable Liquids }

1st October 1981

Victor Petroleum Pty Ltd,  
1 Greenlands Avenue,  
Sandy Bay,  
HOBART

O.N. 07.Reg. Nos 813986-814060

Dear Sir,

Physical Determinations on Diamond Drill Cores.Sandstone, Mudstone and Dolerite.Determinations and Methods.1. Density as received.

Required that the core was not wetted.

Mass of core determined by weighing.

Volume of core determined by averaging 5 measurement of length, one at centre of the cylinder and four at perimeter at the ends of two diameters at right angles to each other, measuring of diameter and calculating volume; hence determining density.

2. Density of Crushed Core.

Core crushed to approximately minus 15mm in jaw crusher, and volume of crushed core measured in glass measuring cylinder, hence determining apparent density.

3. "Absorbed" Water.

Crushed core immersed in water for seven days; then recovered by filtration and filter residue weighed; hence from original mass, retained water determined; in some cases much surface water was present on the filtered core.

Filtration conditions.

15cm Buchner funnel.

Whatman No 1. Filter paper.

5 minutes suction.

Results Sandstones

857059

Reg. No	Sample No	Density		Retained Water	Remarks
		As Rec'd	Crushed	% Orig. Mass	
813986	1	2.31	1.32	19.0	Disint. - mud
987	2	2.28	1.45	16.5	" "
988	3	2.27	1.29	6.9	Partial disint.
989	4	2.32	1.28	9.7	Disint. - mud
990	5	2.30	1.32	9.6	Mostly disint.
991	6	2.29	1.25	7.7	" "
992	7	2.18	1.28	11.8	Partial disint.
993	8	2.24	1.21	13.8	" "
994	9	2.27	1.27	8.9	Mostly disint.
995	10	2.07	1.33	8.5	Partial disint.
996	11	2.20	1.23	13.5	" "
997	12	2.28	1.23	7.3	No disint.
998	13	2.08	1.22	14.1	" "
999	14	2.17	1.24	17.4	Total disint.
814000	15	2.16	1.24	15.2	Partial "
001	16	2.32	1.37	14.8	Disint. - mud
002	17	2.37	1.29	7.5	Slight disint.
003	18	2.36	1.24	8.9	No disint.
004	19	2.30	1.29	8.8	" "
005	20	2.15	1.25	11.3	" "
006	21	2.15	1.32	13.3	" "
007	22	2.24	1.32	11.1	" "
008	23	2.32	1.25	17.2	Disint. - mud
009	24	2.32	1.28	13.3	No disint.
010	25	2.20	1.25	11.9	" "

Note Disint. = Disintegration.

Mudstones

857060

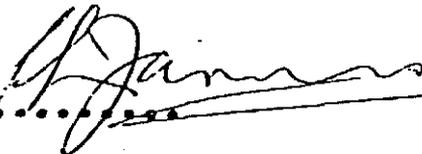
Reg. No	Sample No	Density		Retained Water	Remarks
		As Rec'd	Crushed	% Orig Mass	
814011	26	2.39	1.29	18.4	Mostly slow filtering with significant quantities of free water retained in filter residues, because of slime generated in crushing.
012	27	2.37	1.27	14.0	
013	28	2.39	1.26	8.3	
014	29	2.36	1.26	12.8	
015	30	2.35	1.26	12.8	
016	31	2.40	1.28	15.0	
017	32	2.30	1.21	22.5	
018	33	2.35	1.24	10.4	
019	34	2.34	1.27	11.5	
020	35	2.32	1.27	10.1	
021	36	2.34	1.27	10.9	
022	37	2.39	1.28	7.8	
023	38	2.39	1.35	9.2	
024	39	2.44	1.29	8.8	
025	40	2.42	1.40	10.1	
026	41	2.43	1.31	7.8	
027	42	2.45	1.34	11.0	
028	43	2.34	1.25	12.0	
029	44	2.40	1.38	12.2	
030	45	2.40	1.24	14.1	
031	46	2.35	1.21	14.9	
032	47	2.37	1.24	10.5	
033	48	2.30	1.18	13.1	
034	49	2.21	1.24	12.2	
035	50	2.24	1.20	16.1	

- 4 -  
Dolerites

857061

Reg. No	Sample No.	Density		Retained Water	Remarks
		As Rec'd	Crushed	% Orig. Mass	
814036	51	2.94	1.40	5.0	
037	52	2.95	1.48	5.1	
038	53	2.90	1.55	2.6	
039	54	2.93	1.57	4.6	
040	55	2.81	1.49	4.3	
041	56	2.89	1.49	2.6	
042	57	2.55	1.38	4.2	Mudstone ?
043	58	2.78	1.50	2.6	
044	59	2.77	1.49	3.9	
045	60	2.79	1.61	3.6	Mostly free
046	61	2.79	1.47	5.9	filtering -
047	62	2.72	1.44	2.7	little surface
048	63	2.75	1.39	2.2	water retained
049	64	2.76	1.40	3.8	and very little
050	65	2.84	1.48	3.0	slime generated
051	66	2.75	1.51	1.9	in crushing.
052	67	2.79	1.46	3.6	
053	68	2.74	1.47	2.9	
054	69	2.79	1.42	3.7	
055	70	2.76	1.47	4.5	
056	71	2.73	1.48	4.0	
057	72	2.76	1.40	3.0	
058	73	2.84	1.59	3.1	
059	74	2.83	1.50	2.7	
060	75	2.82	1.65	3.0	

Research Officer.....



(H. K. Wellington)  
Chief Chemist & Metallurgist

PRELIMINARY REPORT ON  
PETROLEUM POTENTIAL - ONSHORE TASMANIA

by T.G. Summons

August, 1981.

PRELIMINARY REPORT ON PETROLEUM POTENTIAL  
- ONSHORE TASMANIA

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ABSTRACT

A review has been made of potential hydrocarbon source and reservoir rocks of Ordovician to Triassic age in Tasmania. The appraisal of post-Cambrian to pre-Tertiary regional geology, in conjunction with current concepts on source rock characteristics, paleo-geothermal gradients, and known occurrences of sapropelic kerogen, implies the presence of potential source rocks at several horizons of differing age and lithology. The most likely hydrocarbon source rocks are the Ordovician Gordon Sub Group (carbonate), and the Carboniferous - Permian section of the Parmeener Super Group (clastic). Recent discoveries of Petroleum seepages were made in the basal section of the Parmeener Super Group; this lower section appears to fulfill the accepted criteria for source rocks, although the limited number of samples collected precludes authoritative conclusions. High heat flow during the Devonian in western and north western Tasmania, and possibly relict as late as Permian time, has effectively down graded the prospectiveness of these parts of the state for hydrocarbon potential.

However, the remainder of the state appears to have been shielded from the high heat flow, as evidenced by the Gordon Limestone in Southern Tasmania, which was subjected to the requisite maturation conditions for the generation of hydrocarbons.

PRELIMINARY REPORT ON  
PETROLEUM POTENTIAL - ONSHORE TASMANIA

by T.G. Summons

August, 1981.

1:0 INTRODUCTION

This review of current literature and ideas of Tasmanian geology, applicable to exploration for liquid and gaseous hydrocarbons, is intended to review some of the aspects of petroleum origin, migration and retention in Tasmania, with the object of rationalising future petroleum exploration programs.

Critical physical and chemical data on potential source and reservoir rocks are either poorly known, or non existent; accordingly, many of the comments made in this report are speculative and will almost certainly be modified after collection, compilation and interpretation of the requisite data.

The report is divided into a discussion of lower Palaeozoic and Carboniferous Permian-Triassic age rocks, under the following headings:-

1. Regional Geology
2. Comments on Source Rock Types
3. Geothermal History
4. Potential Oil Source Rocks
5. Potential Oil Reservoir Rocks

2:0 REGIONAL GEOLOGY

2:1 ORDOVICIAN

The Ordovician period is represented by the Junee Group, which consists of the Denison Sub Group, overlain by the Gordon Sub Group. The type area of the Junee Group is the Florentine Synclinerium (Maydena - Florentine Valley).

2:1.1 Denison Sub Group

This sub group consists of three formations:-

- Reeds Conglomerate 1500m
- Tim Shea Sandstone 300m
- Florentine Valley Mudstone 600m

As the formation names imply, the lithologies consist of conglomerate, sandstone and siltstones with minor impure limestone. A widespread marine transgression occurred at the top of the subgroup, with sand deposited in N.W. and W. Tasmania, while silt was deposited in the Florentine Valley (Florentine Valley Mudstone), suggesting a source area in the N.W. and W. of the state; support for this model is seen in the higher proportion of calcareous beds in the Florentine Valley and Beaconsfield areas, than elsewhere.

2:1.2 Gordon Sub Group

This sub group consists of three formations:-

- Karmberg Limestone
- Cashions Creek Limestone
- Benjamin Limestone (Corbett and Banks, 1974).

The Karmberg Limestone consists of approximately 400m of impure nodular limestone, calcareous siltstone and chert; it is richly fossiliferous, and contains large spherulites of pyrite. The Cashions Creek Limestone consists of approximately 100m of dolomitic limestone with abundant algal colonies (Girvanella).



Gordon Sub Group (Contd.)

The Benjamin Limestone consists of approximately 1200m of dolomitic and stylolitic limestone of variable purity; several horizons rich in corals, stromatoporoids, sponges, cephalopods, brachiopods, and gastropods occur, and are considered by C.F. Burrett (pers. comm.) to represent possible back reefs. The limestones represented by these formations consist of supratidal dolomites, intertidal calcisiltites, and subtidal calcisiltites, calcarenites and shelly/coralline calcirudites. During Chazyan time (Cashion Creek Limestone) algal lawns were widespread across the state, and from Blackriveran through Trentonian to early Cincinnati time (Benjamin Limestone) coral gardens/baffles became widespread.

The depositional environments for the Gordon Sub Group and the upper part of the Denison Sub Group were shallow water/platform. The youngest unit in the Junee Group is the Westfield Beds, consisting of approximately 150m of siltstone and sandstone overlying the Gordon Sub Group.

2:2 SILURIAN - DEVONIAN

2:2.1 Eldon Group

This group consists of formations of three major alternations of sandstone and siltstone, which, with minor limestone, ranges in thickness from 1800m to 2300m.

Thus the Crotty Quartzite is overlain by the Amber Slate, the Keel Quartzite by the Austral Creek Siltstone, and the Florence Sandstone by the Bell Shale.

The general cyclicity of sandstone alternating with siltstone also occurs within each of the major sandstone and siltstone units referred to above.

All Eldon Group lithologies were deposited under shallow marine conditions (including the siltstones); the greater coarseness and the higher sand : shale ratio of the Eldon Group in western Tasmania, imply a source area to the west of the state (Banks, 1962).

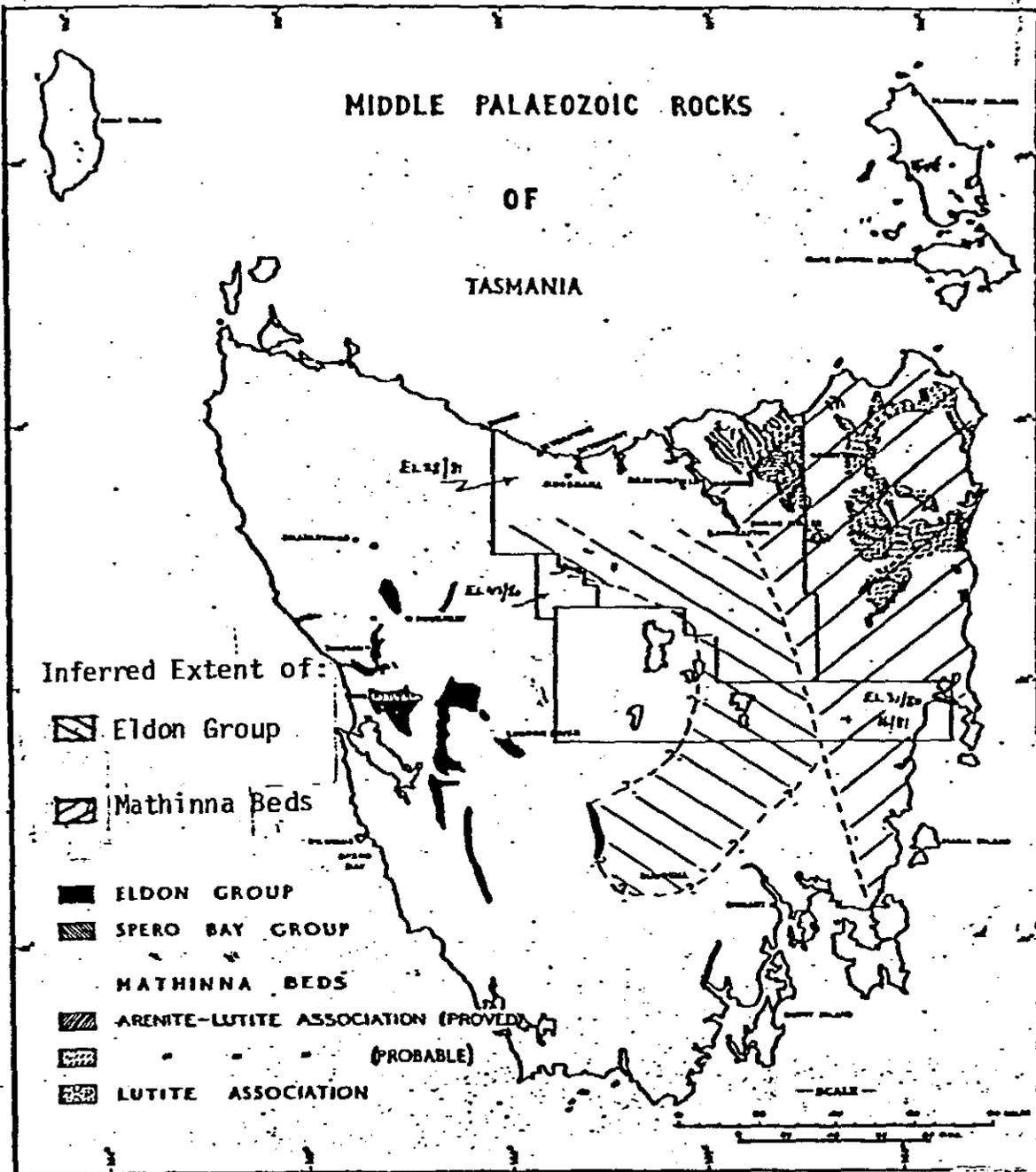


Fig. 2: Distribution of Eldon Group and Mathinna Beds

5 cm

2.2.2 Mathinna Beds

The Mathinna Beds occur in N.E. Tasmania, and consist of more than 2400m of sandstone, siltstone, and mudstone (variably metamorphosed), which were deposited under deep water conditions. A crude twofold subdivision into a sandstone/greywacke - siltstone, and a mudstone association (now slate and phyllite) is recognisable. The age ranges from Ordovician to Devonian, and the sequence shows strong contrasts on faunal and sedimentological grounds with the rest of Tasmania. Banks (1962) postulated a facies change from shallow water shelf type deposition in western Tasmania to continental type deposition in N.E. and E. Tasmania; the margin of the continental shelf is inferred to occur in the vicinity of Flowery Gully. The Mathinna Beds are separated from the rest of Tasmania by a NNW trending transcurrent (?sinistral) fault known as the Tamar Fracture System (Williams, 1979).

2.3 CARBONIFEROUS - PERMIAN - TRIASSIC

2.3.1 Parmeener Super Group

The Lower Parmeener Super Group consists of the Lower Marine, Lower Freshwater and Upper Marine Sequences, with a total aggregate maximum thickness of 1300m (Williams, 1979).

The Lower Marine Sequence includes units such as the Wynyard Tillite, Quamby, Woody Island Siltstone, Darlington Limestone and Bundella Formations, and the Golden Valley and Masseys Creek Groups. Typical rock types are dark coloured siltstone and mudstone (often carbonaceous) with minor limestone, sandstone, conglomerate, and oil shale ("Tasmanite"). Uraniferous, pyritic black shales (some of which are oil shales) occur at Rossarden, and may represent marginal marine conditions at the junction of the Quamby Formation and the Basal Conglomerates in N.E. Tasmania.

The environment of deposition was medium to shallow depth marine, cold (as indicated by the Wynyard Tillite, glendonites and rare dropstones in the overlying formations), and anaerobic, as indicated by the abundant pyrite.

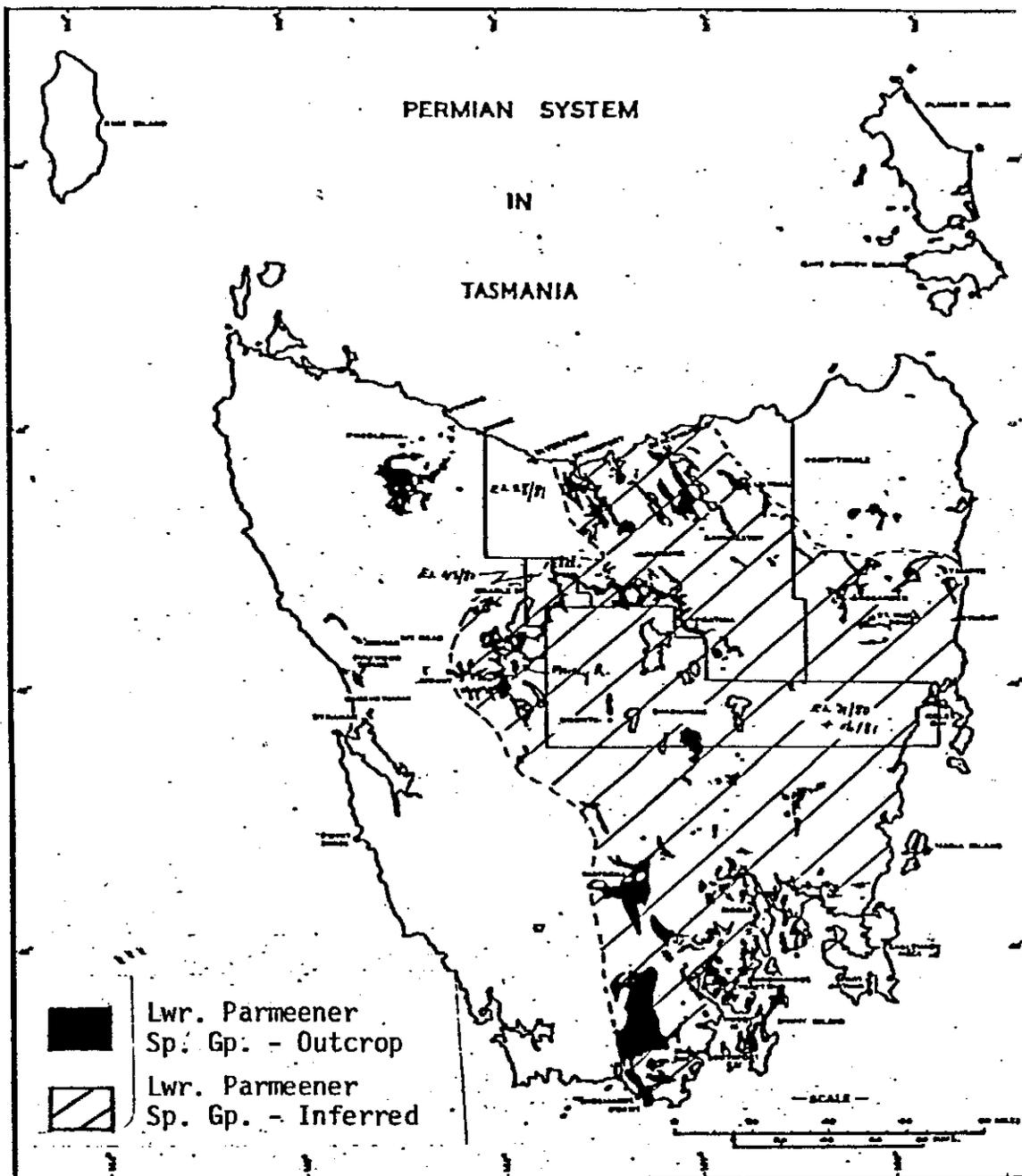


Fig. 3: Distribution of the Lower Parmeener Super Group

TABLE 1

PARMEENER SUPER GROUP

Upper Parmeener Super Group (Upper Freshwater Sequence)

1:250,000 Map Sheet	Locality	Cygnets Coal Measures (m)	Ross Form'n (m)	Cluan Form'n (m)	Tiers Form'n (m)	Brady Form'n (m)	Total (m)
Hobart	-	ND	ND	ND	ND	ND	ND
Oatlands	(Poatina Great Lake)	60	200	140	90	165	655
Launceston	Quamby	ND	ND	ND	ND	ND	580
Burnie	West.Bluff	ND	ND	ND	ND	ND	630
Queenstown	Cent. Plat.	ND	ND	ND	ND	ND	365
Average:							550

Lower Parmeener Super Group (Lower Marine, Lower Freshwater and Upper Marine Sequences)

1:250,000 Map Sheet	Locality	Lower Marine Sequence				Lower Fresh- Seq. (m)	Upper Marine Seq. (m)	Total (m)
		Tillite (m)	Silt/ms (m)*	SS/Silt/LS (m)	Sub Tot. (m)			
Hobart	Cygnets/ Glenorchy	300	200	100	600	30	300	930
Oatlands	Poatina/ Friendly Beaches	105	90	60	255	110	280	645
Launceston	Quamby	ND	ND	ND	350	45	265	660
Burnie	Wynyard/ West.Bluff	490	135	60	685	36	260	981
Queenstown	Central Plateau/ Florentine Valley	45	ND	ND	ND	ND	ND	ND
Averages:		235	142	73	472	55	276	804

(\* Includes the Woody Island Siltstone and "Tasmanite" horizons)

Maximum Thickness preserved: 655 + 981 = 1636m (≈ 1.6m).  
This contrasts with the figure given by Williams (1979) of 1930m.

The Lower Fresh-water Sequence includes the Mersey and Prelonna Coal Measures, with an average thickness of 30m. Typical lithologies are sandstone, carbonaceous siltstone and coal; oil shale and cannel coal occur near the top of the sequence, adjacent to the Malbina Formation.

The Upper Marine Sequence includes the Cascades Group, the Malbina Formation, Risdon Sandstone, Ferntree Mudstone and Poatina Group. Lithologies range from calcareous siltstone and limestone to siltstone and mudstone, with minor arkosic and glauconitic sandstone.

The environment of deposition was probably similar to that of Lower Marine Sequence, namely medium/shallow water shelf conditions; the climate was cool as indicated by rare glacial dropstones.

The Upper Parmeener Super Group consists of the Upper Freshwater Sequence with a total maximum thickness of approximately 650m (Williams, 1979). It includes the Cygnet Coal Measures, Ross, Cluan, Tiers and Brady Formations.

Lithologies range from quartzose to lithic sandstone, siltstone, carbonaceous to grey/green mudstone, to coal and acid/intermediate volcanics.

The environment of deposition was similar to that for the Lower Freshwater Sequence - continental and freshwater (lacustrine).

Parmeener Super Group localities and thicknesses are shown in Table 1, where it should be noted that the apparent maximum preserved thickness is approximately 1600m.

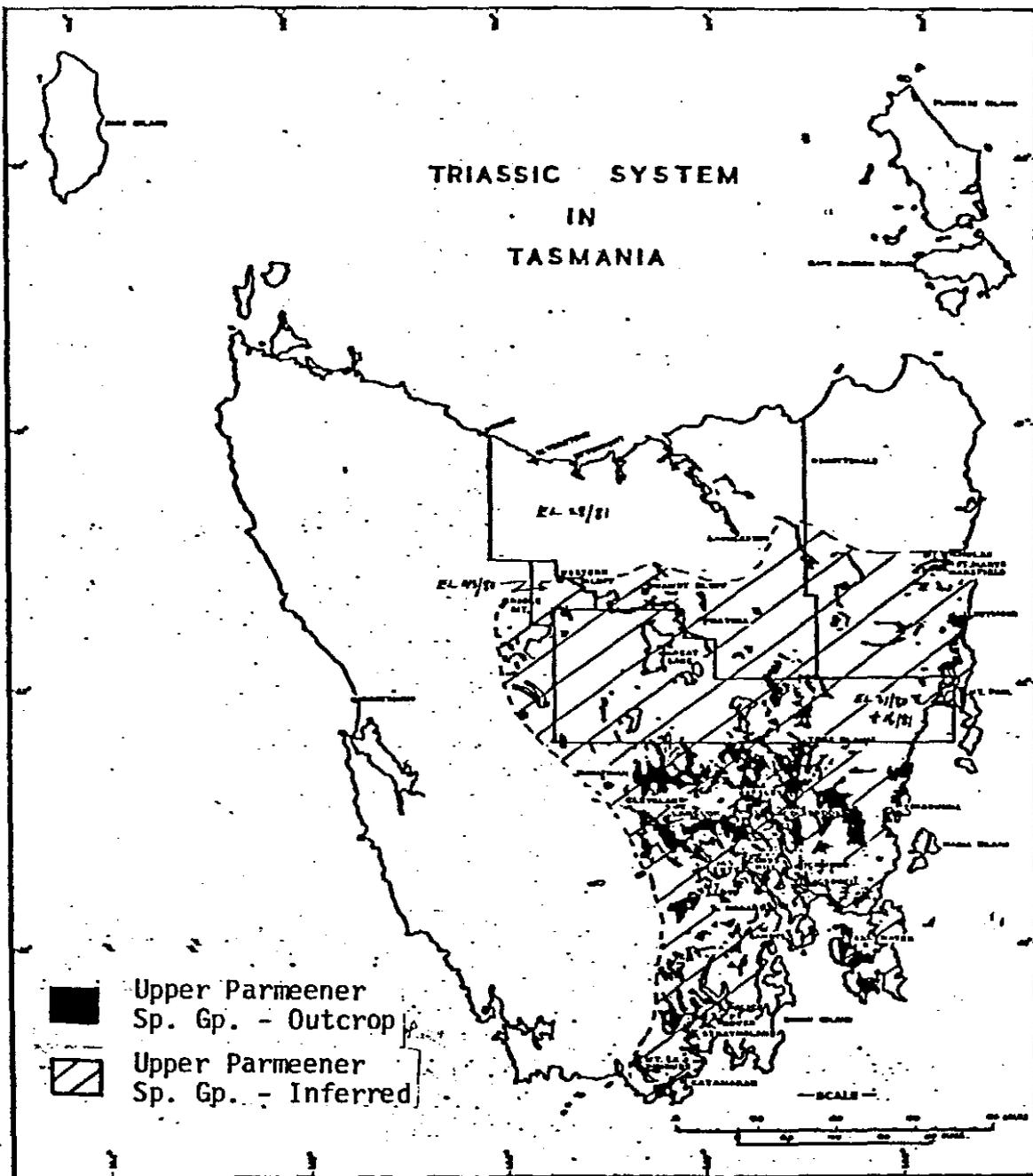


Fig. 4: Distribution of the Upper Parmeener Super Group

5 cm

3:0 COMMENTS ON SOURCE ROCK TYPES

3:1 CARBONATE

3:1.1 Pure limestones are able to generate heavy oil with the requisite maturation conditions, and organic matter (OM) content. Impure limestones, containing more clay minerals (to act as Lewis Acid Catalysts) would modify the tendency to produce heavy oil (Hunt, 1979). The Karmberg Limestone contains  $\approx 75-85\%$   $\text{CaCO}_3$  while Cashions Creek Limestone contains  $\approx 93\%$   $\text{CaCO}_3$ , and the Benjamin Limestone  $\approx 85-90\%$   $\text{CaCO}_3$ .

3:1.2 Dark or brown coloured limestone/dolomite is generally a good source rock; most of the Karmberg, and some of the Cashions Creek and Benjamin Limestones are impure and argillaceous. Litho correlates of these units at Lune River (Summons, 1981), are similarly dark brown, with bituminous stylolites, disseminated pyrite, and with interbeds of carbonaceous phosphatic shale/siltstone. Bituminous stylolites are recorded from several localities in the Gordon Limestone (e.g., Railton, Deloraine).

3:1.3 Fine grained carbonate rocks generate more hydrocarbons from the same amount of total organic matter (TOM) than a clastic source rock, because limestones contain sapropelic OM (rich in algal/amorphous kerogen). These kerogen types have the highest H/C ratio, and thus the highest yield of petroleum of all the kerogens (Hunt, 1979).

The Gordon Limestone is essentially fine grained (micrites and calcisiltites) across the state, and this feature is important in maximizing the amount of associated OM within it.

3:1.4 Typical source beds were formed in low energy coastal marine environments, where clays and carbonates were deposited with 0.5-5% OM. The critical factor in preservation of the OM is the existence of toxic, anaerobic conditions. Sapropelic OM, which was formed in marine environments, is able to generate both oil and gas.

The Gordon Limestone was formed under shallow water, marine conditions (as discussed previously), and the frequent occurrence of pyrite in conjunction with the carbonaceous shales implies an anerobic and toxic environment.

- 3:1.5 A possible parallel of the Karmberg-Cashions Creek Limestones (Florentine Valley) and the Lower Sequence at Lune River exists in the lower part of the Marl Slate of N.E. England (Turner et al, 1978), where the sapropelic facies (laminated siltstone, dolomite and bitumen) is overlain by evaporite facies sediments. Details on the evaporitic nature of the Middle Sequence at Lune River were described by Summons (1981).
- 3:1.6 Catalytic cracking of hydrocarbons can be induced by salts of V, Mo, Ni (Levorsen, 1966); the black shales in the Gordon Limestone at Lune River are phosphatic, and anomalous in their content of Mo and Ni.
- 3:1.7 The association of oil brines with hypersaline dolomitizing brines responsible for the formation of the Mississippi Valley Type ore deposits has been noted by several authors, e.g. Hall and Friedman (1963), Hall and Heyl (1968), and Carpenter et al (1974).

Dolomitization of the Gordon Limestone has occurred at several localities, and a mechanism of transport of any oil that may have been generated may be envisaged.

### 3:2 CLASTIC

- 3:2.1 Catalytic cracking of hydrocarbons is a significant process in the generation of petroleum below  $\approx 125^{\circ}\text{C}$  (Goldstein, in Hunt, 1979); typical naturally occurring catalysts are smectite clay minerals and zeolites. Levorsen (1966) cites an example of polymerization of propylene at  $35^{\circ}\text{C}$  in response to natural catalyst bearing rocks.

The Lower Marine Sequence of the Parmeener Super Group is reported to contain altered glass shards in southern Tasmania and the Upper Marine Sequence (Cascades Group) contains beds of bentonite, (Banks, 1962). These occurrences are interpreted as indicating volcanism (possibly that recorded in N.S.W.), during the Permian, and the original presence of zeolitized tuffs may be inferred.

The original presence of smectite clays in the Lower Marine Sequence is currently unknown, but the concept of smectite/zeolite initiated catalytic decomposition of OM may have been significant in view of the geothermal gradients estimated for the Permian in Tasmania.

3:2.2 Sapropelic OM is formed by decomposition and polymerization of spores and planktonic algae, and may be converted to one of the following with increasing maturation; boghead coal/oil shale, cannel coal, or oil. Sapropelic OM is known to occur in both the Lower and Upper Marine Sequences of the Permian Super Group as follows:

- (a) The "Tasmanite" oil shale from N. and N.W. Tasmania (Quamby Formation) consists of a single celled alga named Tasmanites Punctatus, which has H/C ratio of  $\approx 1.5$ , and an O/C ratio of  $\approx 0.12$ .

As stated previously, sapropelic organic matter is the most productive generator of oil, because its kerogen constituents (algal, amorphous and herbaceous) can contribute H in the range of H/C from 1.7 - 0.30. Thus the "Tasmanite" oil shale may be viewed as representing the optimum type of source rock OM.

- (b) Banks (1962) recorded oil shale and cannel coal from the top of the Mersey Coal Measures; however, it is equally possible that these occurrences of sapropelic OM occur at the base of the overlying Malbina Formation; similar comments (to those made for "Tasmanite" oil shale), apply as to the petroleum prospectiveness of this OM, given the necessary maturation conditions. The presence of cannel coal (world ave. H/C  $\approx 1.0$ , O/C  $\approx 0.11$ ) suggests that it has progressed along the maturation pathway from the "Tasmanite" oil shale.

3:2.3 Radioactive elements may aid in the transformation of kerogen to petroleum through the action of alpha particle bombardment (Levorsen, 1966); however, the evidence for the significance and extent of such transformation is conjectural.

Uraniferous black shales occur beneath the Permian Basal Conglomerate (and possibly in the Quamby Formation) at Rossarden.

4:0 GEOHERMAL HISTORY

The geothermal history of a basin involves an analysis of the time intervals during which the sediments were subjected to various temperatures. It represents the optimum mode of evaluating hydrocarbon generation in a basin, providing reasonable palaeo temperatures can be established.

The three main optical organic metamorphism indices are vitrinite reflectance, palynomorph colour change (Thermal Alteration Index - TAI), and conodont colour change (Colour Alteration Index - CAI). The colour and preservation of palynomorphs is a function of the thermal alteration (Staplin, 1969), but it is only recently that Epstein et al (1977) and Harris (1979) have demonstrated that the conodont colour is similarly temperature dependant. These authors have correlated colour changes with the amount of fixed C in the conodonts and the host sediments; the conodonts darken with increasing temperature as a result of carbonization of the OM in the inter lamellar spaces. Further indications of the potential of using CAI values were summarised by Harris (1979) as follows:-

- (a) Conodont colour alteration is progressive, cumulative and irreversible.
- (b) The colour alteration is dependant on time and temperature, but is independent of pressure.
- (c) An Arrhenius plot of experimental and field data indicate that colour alteration of conodonts ranges from 50-450°C.
- (d) Time is of minor importance for CAI values in rocks older than 50 million years.
- (e) The 6 CAI values can be correlated with vitrinite reflectance, translucence photometry, and chemical analyses.

5:0 PALAEO - GEOHERMAL GRADIENTS

5:1 Gordon Sub Group

Burrett (1978) showed that CAI values in the Gordon Limestone vary considerably across the state, outlining an arcuate trend around the Precambrian blocks of central Tasmania. This arcuate trend follows Cambrian volcanics and lower Palaeozoic synclinoria, which both fringe and overlie the Precambrian blocks (Cradle Mtn., Prince of Wales blocks).

The Cambrian volcanics (which host the major base metal orebodies of Mt. Lyell, Rosebery, etc.), have been interpreted as an island arc adjacent to an east plunging subduction zone (Solomon and Griffiths, 1974), and more recently as a rift valley-caldera structure by Corbett (1979).

The zone of darkest Ordovician conodonts (Flowery Gully, Melrose, Loongana, Everlasting Hills, Olga synclinorium), coincides with a belt of thinned Cambrian crust (represented by the Mt. Read Volcanics, Dundas Group, etc.), and a belt of maximum deformation in Gordon Sub Group localities. The Cambrian geothermal gradient would have been appreciably higher within this region of thinned crust, and assuming this region was not underlain by Precambrian crust, high heat flows would have occurred in post-Cambrian times.

The corollary to this interpretation is that post-Cambrian rocks, floored by Precambrian crust, would have been relatively insulated from the postulated high heat flow values within the Cambrian volcanics.

Table 2 depicts CAI, change ( $\Delta$ ) in temperature, thickness and geothermal gradients ( $\beta$ ) for the Gordon Limestone. No gradients appear to have existed across the Gordon Limestone at Flowery Gully, Melrose, Gunns Plains and Everlasting Hills as indicated by the CAI values. The Gordon Limestone in these areas was heated to  $> 300^{\circ}\text{C}$ , and a consideration of the maximum depth of burial by post-Ordovician rocks implies the presence of abnormally high geothermal gradients. A high, post-Ordovician (probably middle Devonian) heat flow is assumed for W. and N. Tasmania for the following reasons:

- (i) In several localities (referred to previously), the "normal" geothermal gradient due to depth of burial (with attendant increase in temperature), does not exist, suggesting that it has been obscured by another source of thermal energy. The lowest CAI values in, and the lowest geothermal gradients across, the Gordon Limestone occur in those areas floored by Precambrian crust; other areas marginal to the Cambrian volcanics (e.g. Mole Creek, Olga River) have intermediate geothermal gradients.

TABLE 2

## ORDOVICIAN (GORDON SUB GROUP) SAMPLES

Locality	C.A.I.		Min. $\Delta$ Temp. (°C)	Max. $\Delta$ Temp. (°C)	Thickness (km)		$\beta$ Min. (°C/km)	$\beta$ Max. (°C/km)
	Base	Top			Present	+ 35%		
Flowery Gully	5	5	-	-	0.47	0.72	-	-
Melrose	5	5	-	-	?0.25	?0.39	-	-
Gunns Plains	4	4	-	-	0.90	1.39	-	-
Loongana	5	4	100	210	0.65	1.00	100	210
Mole Creek	5	3	100	290	1.30	2.00	50	145
Mole Creek*	4	3	<80	190	1.30	2.00	<40	95
Bubs Hill	5	3	100	290	0.35	0.54	185	537
Everlasting Hills	5	5	-	-	0.25	0.39	-	-
Olga River	5	4	<100	210	1.50	2.31	<43.3	90.9
Florentine Valley	4	2	50	240	1.70	2.62	19.1	91.6
Lune River	2	1	20	90	>0.70	>1.08	<18.5	<83.3
Average Mole Creek* and Olga River:							41.6	92.9
Average Florentine Valley & Lune River							18.8	87.4

- NB: (i) CAI - Conodont Colour Alteration Index
- (ii) Thickness recalculated to allow for volume reduction due to pressure solution (diagenetic and tectonic stylolites).
- (iii)  $\beta$  - Geothermal gradient within Gordon Limestone, before volume reduction (shortening). The  $\beta$  values shown here are reproduced as  $\beta$  values in Table 4.
- (iv) CAI data from Burrett (1978), and change in temperature ( $\Delta$ ) from Harris (1979).

- (ii) Lower Devonian conodonts, in rocks which were unlikely to have been buried to any appreciable depth, have been metamorphosed (Burrett, 1978).
- (iii) The K-Ar ages of late Devonian granite have not been reset by heat induced leaking of Ar; however, the K-Ar ages of late Cambrian granites have been reset to Ordovician ages (McDougall and Leggo, 1965), presumably by Devonian heating.

Thus the best estimates of the "normal" (due to depth of burial alone), geothermal gradient across the Gordon Limestone, are the values indicated for Florentine Valley and Lune River (Table 2), which range from  $19^{\circ}\text{C}/\text{km}$  to  $87^{\circ}\text{C}/\text{km}$ , with an average of  $53^{\circ}\text{C}/\text{km}$ .

The average of the Mole Creek (less altered sample) and Olga River samples indicates a geothermal gradient of  $42\text{--}93^{\circ}\text{C}/\text{km}$  and an average of  $67^{\circ}\text{C}/\text{km}$ . Inclusion of the more altered sample from Mole Creek indicates an average value for the two areas of  $77^{\circ}\text{C}/\text{km}$ .

The CAI values for Flowery Gully, Melrose, Gunns Plains and Everlasting Hills indicate heating to  $> 300^{\circ}\text{C}$  for the entire Gordon Limestone, which compares with temperatures of  $\approx 200^{\circ}\text{C}$  and  $\approx 80^{\circ}\text{C}$  at the top of the Gordon Limestone, in the Mole Creek/Olga River, and Florentine Valley/Lune River areas respectively.

If it is assumed that the rocks overlying the Gordon Limestone were similar in thickness and thermal conductivity, and that the Gordon Limestone had approximate constant thermal conductivity, then temperature is proportional to heat flow; accordingly, the CAI data imply that the Devonian heat flow (relative to Florentine Valley/Lune River), was 150% and 275% higher in the Mole Creek/Olga River and Flowery Gully, etc. areas respectively.

5:2 Parmeener Super Group

Harris (1981) examined samples collected by Victor Exploration Pty. Ltd. staff from several localities in the Lower Marine Sequence of the Parmeener Super Group. AMDEL (1981) analysed 10 out of 12 samples collected, and Harris (1981) was only able to find herbaceous kerogen in 5 of the 10 samples, and consequently, could only assign reliable TAI values to half the samples. This data is shown in Table 3, which also depicts change in temperature, thicknesses, and geothermal gradients for the Parmeener Super Group and Jurassic dolerite.

Although it is not possible to construct TAI isograds from the limited number of samples, it is apparent that those samples collected from the N.W. of the state (Bronte, Mersey River) show higher thermal maturity than those elsewhere in the state (Poatina, Quamby Brook, Maydena). Inclusion of the 5 samples devoid of kerogen (and assuming the inferred TAI values are valid), generally enhances the thermal maturity pattern described above, the exception being the Poatina Power Station sample, the true location of which cannot be determined.

This pattern may be a reflection of a relict, high Devonian heat flow as discussed previously.

Similarly to the Gordon Limestone samples, the problem in determining the "normal" geothermal gradient during Permian and subsequent time appears to be one of screening out the effects of high heat flow; accordingly, the best estimate of the "normal" geothermal gradient can be obtained from the Maydena/Styx River area (Sample 12A), which ranges from 28-50°C/km, and has an average of 39°C/km. The Quamby Brook - Poatina areas range from 32-70°C/km (average 57°C/km.).

Although the number of useful (herbaceous kerogen bearing) samples is inadequate to permit statistically reliable conclusions to be made about the thermal history of the Parmeener Super Group, the following observations may be of possible significance:

TABLE 3

PERMIAN SAMPLES

Sample	Locality	TAI	Min. Δ Temp (°C)	Max Δ Temp (°C)	Thickness			β Min. (°C/km)	Max. β (°C/km)
					PSGp	Dol.	Total		
4/6	Mersey River	(4)	-	-	-	-	-	-	
5	Mersey River	3	100	155	0.86	0.50	1.36	73.5	114.0
7	Bronte	3	100	155	1.20	0.50	1.70	58.8	91.2
11	King William Saddle	(4)	-	-	-	-	-	-	
12	Styx River	(4)	155	200	1.30	0.70	2.00	(77.5)	(100.0)
12A	Styx River	≈ 2	≈ 50	≈ 90	1.10	0.70	1.80	27.8	50.0
1	Hobart	-	-	-	-	-	-	-	
2	Quamby Brook	2	< 40	100	1.29	0.50	1.79	< 22.3	55.9
3	Poatina	(4)	155	200	1.20	0.50	1.70	(91.2)	(117.6)
8 )	Poatina } 27m	2 )	< 30	60	0.22	0.50	0.72	< 41.7	83.3
9 )	HEC DDH } 5021 ) 242m	3 )							
Average for W. Tasmania (Samples 5,7)								66.1	102.6
Average for N.E. Tasmania (Samples 2,8,9)								32.0	69.6
Apparent oil threshold (Maydena, Sample 12A)								27.8	50.0
Average for S. and N.E. Tas. (Samples 12A, 2, 8, 9)								30.6	63.1

- NB:
- (i) TAI - Thermal Alteration Index; values in brackets are estimates only, as the samples did not contain any herbaceous kerogen.
  - (ii) PSGp - Parmeener Super Group thickness from the top of the Wynyard Tillite, except for sample 12A, for which the thickness was taken from the top of the Woody Island Siltstone correlate.
  - (iii) Sample 12A is from the Woody Island Siltstone correlate, Maydena.
  - (iv) Maydena section (above Wynyard Tillite) taken as 630m. (lwr. PSGp), 640m. (upper PSGp) and 700m. (J. dolerite). The section above the Woody Island Siltstone correlate excluded this unit (200m).
  - (v) β - Geothermal gradient, calculated assuming a ground temperature of 100°C. The β values shown here are reproduced as β<sub>2</sub> values in Table 4.

TABLE 4

ESTIMATED GEOTHERMAL GRADIENTS (ORDOVICIAN - JURASSIC) - TASMANIA

Locality	Thickness (k/m)				Ave. Geothermal Gradient (°C/km)			
	Dolerite	PSGp	E.Gp.	Og.				
Quamby/Poatina Mole Creek	0.5	1.3	<1.0	1.3	51	>52	<68-69	57-67
Olga River	(0.5)	(1.5)	2.0	1.5	(75)	(59)	67	(61)
Maydena/ Florentine Valley	0.7	1.6	2.0	1.7	39	21	55	31
Lune River	0.5	1.6	(-)	>0.7	39	19	<51	<27
Average for Sthl. Tasmania:					39	20	53	29

- NB:
- (i) PSGp - Parmeener Super Group (Including Wynyard Tillite).
  - (ii) E. Gp. - Eldon Group (Silurian - Devonian).
  - (iii) Og - Gordon Sub Group (Ordovician)
  - (iv) Geothermal gradients,  $\beta =$ 
    - $\beta_2$  = Average geothermal gradient across dolerite + PSGp to the top of the Wynyard Tillite.
    - $\beta_1$  = Average geothermal gradient across dolerite, PSGp (total) and E.Gp.
    - $\beta_0$  = Average geothermal gradient across Og (Original thickness).
    - $\beta_T$  = Average geothermal gradient from dolerite to the base of Og (present thickness).
  - (v) The original thicknesses of dolerite and PSGp in the Olga Synclinerium are unknown, and are assumed to have been similar to the Bronte data, with 300m. of Wynyard Tillite. Similarly, the  $\beta_2$  value was taken as the Bronte value; accordingly, the  $\beta_2$ ,  $\beta_1$ , and  $\beta_T$  values for the Olga River, are only very approximate, although the  $\beta_1$  and  $\beta_T$  figures are notably similar to those for the Quamby/Poatina/Mole Creek area.

- (i) The geothermal gradient across the Gordon Limestone in the Mole Creek/Olga River areas was  $\pm$  26% higher than the gradient in the Florentine Valley/Lune River areas.
- (ii) The geothermal gradient in the Mesozoic in the Quamby Brook/Poatina areas was  $\pm$  30% higher than the gradient at Maydena.

All palaeo-geothermal data is shown in Table 4, which was compiled from Tables 1, 2 and 3, and from Figure 1.

#### 6:0 MODERN GEOTHERMAL GRADIENTS

Surface heat flow ( $Q$ ) is measured in units of  $W/m^2$ , and related to thermal conductivity ( $\lambda$ , in units of  $W/m/^\circ C$ ) and the geothermal gradient ( $\beta$ , in units of  $^\circ C/m$ ) by the expression  $Q = \lambda\beta$ .

Currently, Tasmania has an abnormally high heat flow which is approximately twice the world average of  $60mW/m^2$ . Evidence for this comes from the work of Newstead and Beck (1953), Jaeger and Sass (1963), Wronski (1977), Lilley, Sloane and Sass (1977), Cull (1979), Cull and Denham (1979), and Nicholas, Rixon and Haupt (1980).

Lilley et al (1977) produced a heat flow map for Australia, and reported the following  $Q$  values (in  $mW/m^2$ ) for Tasmania:

- Rosebery (Cambrian schist) = 120
- Glenorchy (Parmeener Super Group - Cambrian Volcanics) = 87
- Storeys Creek (Mathinna Group Sediments) = 150
- Central Plateau (dolerite) = 75 - 100

There are no known measurements of heat flow in granitic rocks in the state.

Cull (1979) assigned eastern Tasmania to the Eastern Australian Heat Province, while Cull and Denham (1979) observed that the heat flow anomalies in Tasmania were apparently unrelated to surficial deposits of uranium; they reported the heat flow in Tasmania to range from  $85-110mW/m^2$ .

The majority of the geothermal gradients measured in Tasmania are in excess of  $30^{\circ}\text{C}/\text{km}$  (D.C. Green, pers. comm.). Nicholas et al (1980) produced an uncorrected geothermal map of Australia, and reported the measurements of geothermal gradients from 5 Bass Basin oil wells, which averaged  $35^{\circ}\text{C}/\text{km}$ .

However, corrections for mud circulation effects (cooling) in the holes were not applied (+10, +14%, D.C. Green, pers. comm.), nor were corrections for climatic controls, as discussed by Cull (1979). Cull observed that variations in the geothermal gradient were caused by surface warming following the retreat of the Pleistocene glaciers in Southern Australia, and estimated positive corrections of 10-25% for all geothermal data obtained from depths of  $< 300\text{m}$ .

Assuming that the Bass Basin oil well measurements were made at depths  $> 300\text{m}$ , the only correction to be made to the data is that for mud circulation, i.e., the geothermal gradient in Bass Basin is approx.  $35+10\%$  to  $35+14\%$   $^{\circ}\text{C}/\text{km}$ , which is approximately  $40^{\circ}\text{C}/\text{km}$ . Thus the present geothermal gradient for Tasmania would appear to range from  $30-40^{\circ}\text{C}/\text{km}$ .

The generally higher heat contents of granite rocks is a function of the concentration of naturally radioactive elements (K, U, Th) which are concentrated in the upper portion of the earth's crust, and contribute  $\geq 50\%$  of the heat flow measured at the surface.

In a recent gamma ray survey of granite rocks in Tasmania conducted by the Geological Survey of Tasmania and the B.M.R., by Collins, Wyatt and Yeates (1981, in press), the granites were found to be areas of high heat productivity with  $\text{U} < 25\text{ppm}$ , and  $\text{Th} < 50\text{ppm}$ . These values are clearly elevated from the world averages for granite of  $\text{U} \approx 5\text{ppm}$  and  $\text{Th} \approx 17\text{ppm}$  (Levorsen, 1974).

The high heat flow in the Tasmanian crust is probably due to two factors:-

- (i) The abundance of granitic rocks, as indicated by gravity surveys (Leaman, Richardson and Shirley, 1980), with apparently anomalous levels of U and Th as discussed above.
  
- (ii) The combinations of thin crust overlying abnormally hot, conductive mantle. Electric conductivity anomalies in Bass Strait and northern Tasmania were reported by Lilley (1976). Sutherland (1981) postulated that northward migration of Australian continental plate has controlled volcanism in Queensland, New South Wales, Victoria and Tasmania, from the start of the Tertiary period 55 million years ago (i.e. the Gondwanaland break up). He suggests that volcanism has occurred as the Australian plate passed over a fixed mantle magma source ("hot spot"), and that the present heat flow anomalies are due to magmatism (crust/mantle), and extension of the crustal plate.

Further discussion on the high heat flow in Tasmania is made in the Appendix.

7:0 POTENTIAL OIL SOURCE ROCKS

7:1 GORDON SUB GROUP

The Gordon Limestone is fine grained, often dark coloured, impure/ argillaceous, and frequently has bituminous stylolites. The most likely source rocks would be the Karmberg and Cashions Creek Limestones (or their correlates), particularly the algae rich Cashions Creek limestone. Beds of pyritic, carbonaceous shale/siltstone imply the requisite toxic, anaerobic conditions existed for the preservation of organic matter.

The type and amount of OM is not known, but it can be predicted as being sapropelic.

Although pure limestones have a higher threshold temperature for petroleum generation than clastic source rocks, the impure nature of the Gordon Limestone, and the Mo, Ni bearing carbonaceous phosphatic shales would offset this effect.

The geothermal history of the Gordon Limestone varies considerably across the state; lowest geothermal gradients occurred in the south, and highest in the west and north west. The low values are believed to be representative of the normal geothermal gradient in those regions underlain by Precambrian crust.

The effect of these Ordovician geothermal gradients in terms of generation of hydrocarbons has to be viewed in context of the total sequences in given areas, as shown in Figure 1.

The optimum generation of petroleum from Gordon Limestone potential source rocks would have occurred in Southern Tasmania (based on present data - the thermal history of the inferred Gordon Limestone in eastern Tasmania is currently highly speculative.

Using the 60-150°C temperature interval to represent the interval of oil generation, and 150-200°C to represent the interval of gas generation (from Hunt, 1979), the following observations can be made:-

- 7:1.1 Florentine Valley - Oil would have been generated from the Benjamin and possibly the Cashions Creek Limestones, and gas from the Karmberg Limestone.
- 7:1.2 Lune River - Oil would have been generated from the basal portion of the Middle Sequence, and all of the Lower Sequence (which includes an algae rich litho correlate of the Cashions Creek Limestone).
- 7:1.3 Mole Creek - Mainly gas, with very minor oil, would have been generated from the upper half of the sequence. Other areas of Gordon Limestone in the state appear to have been very hot, and any organic matter present would have been metamorphosed to pyrobitumen; however, minor gas occurrences may be present.

7:2 PARMEENER SUPER GROUP

7:2.1 Lower Marine Sequence

This sequence is one of fine grained, dark coloured (often carbonaceous), pyritic clastics, with minor sandstone and limestone; it is variably fossiliferous, and toxic, anaerobic conditions are implied by the pyritic, carbonaceous nature of the sediments (i.e. preservation of organic matter). The nature and amount of OM is not known with a high level of statistical significance, but of 12 samples analysed by AMDEL (1981) and examined by Harris (1981):-

- (i) The clastic samples (11) contained an average of 0.74% TOC, and the only carbonate sample contained 0.44% TOC.
- (ii) The clastic samples contain sapropelic kerogen in the range 30-95%, averaging 58%; coaly kerogen averages 40%, which is in contrast to the comments made by Harris (1981).
- (iii) The clastic samples contain EOM in the range 44-192 mg/gTOC, averaging 96 mg/gTOC.
- (iv) Only half the clastic samples contained herbaceous kerogen, so that only half the samples have reliable TAI values.

Clastic source rocks generally require  $> 0.4\%$  TOC (Hunt, 1979) and carbonate source rocks require  $> 0.2\%$  TOC (Ruth and Cooper, 1976). Extractable organic matter (EOM) in source rocks should be  $> 150\text{mg/g}$  TOC (Tissot et al, 1974) or  $> 200\text{ mg/g}$  TOC (Ruth and Cooper, 1976), although the latter authors observed that a significant quantity of EOM is insufficient by itself to identify a source rock.

Liquid hydrocarbons have recently been discovered by M.C. Forster and R. Hine in the Woody Island siltstone Formation correlate at Maydena. A single sample from this locality contained  $1.19\%$  TOC,  $80\%$  sapropelic kerogen, and  $192\text{ mg/g}$  TOC of EOM; the sample was assigned by TAI value of 4 by Harris (1981), but did not contain herbaceous kerogen.

Liquid hydrocarbons have also recently been located (M.C. Forster, pers.comm.) at Poatina and at the head of the Mersey River; the Poatina sample contained  $0.62\%$  TOC,  $70\%$  sapropelic kerogen,  $122\text{ mg/g}$  TOC of EOM, and has a TAI value of 4; the Mersey River samples average  $0.85\%$  TOC,  $58\%$  sapropelic kerogen,  $91\text{ mg/g}$  TOC of EOM, and have TAI values of 3 and 4.

However, all these TAI values of 4 are not based on palynomorph colours, and are enigmatic in view of the apparent source nature of the rocks. Alternatively, if the TAI values are reliable, it suggests the rocks sampled are reservoirs, although the other source rock parameters (TOC, EOM, etc.) indicate them to be a source rocks (particularly the Woody Island Siltstone Correlate at Maydena). The Mersey River sample with the TAI value of 3 seems a plausible indication of a source rock from which petroleum has been produced. Oxidation and irradiation of palynomorphs may also complicate the interpretation of TAI values.

Oil shale ("Tasmanite") occurs in the north of the state near the base of the Quamby Formation; oil shale is also known at Rossarden (probably the Quamby Formation). The inter relationships between the "Tasmanite" oil shale, other oil shales and the petroleum occurrences, in the Lower Marine Sequence are not known at present, and a knowledge of such relations appears imperative to the understanding of the hydrocarbon potential.

NB: TOC: Total Organic Carbon

7:2.2 Upper Marine Sequence

This sequence is one of limestone, mudstone, siltstone and sandstone; on present knowledge, the sequence as a whole would not appear as prospective for source rocks as the Lower Marine Sequence. Potential source rocks appear restricted to the carbonaceous mudstones and the impure limestones.

Oil shale and cannel coal occur at the interface of the Mersey Coal Measures and the Malbina Formation. No analytical data is available for these concentrations of sapropelic organic matter; however, the presence of cannel coal suggests a higher level of maturation than the "Tasmanite" oil shale.

The significance of this occurrence of sapropelic OM apparently much younger than the Woody Island Siltstone Formation - "Tasmanite" oil shale horizon has yet to be thoroughly evaluated.

The geothermal history of the Parmeener Super Group (similarly to the Gordon Limestone) varies considerably across the state; lowest geothermal gradients occur at Quamby Brook, Poatina and Maydena, and highest values occur in the Bronte and Mersey River areas. Similarly to the Gordon Limestone, the minimum geothermal gradients are believed to represent the "normal" values while the higher gradients may reflect a relict high Devonian heat flow.

The effect these geothermal gradients had on the generation of hydrocarbons can be elucidated from Figure 1. Values range from 39°C/km (Poatina, Maydena) to 62°C/km (Poatina) and 84°C/km (average for Bronte and Mersey River). Using the data in Table 3, it is apparent that most of the occurrences of the Lower Marine Sequence have undergone the requisite maturation histories for petroleum generation. This observation may explain the "petroliferous odour" noted in the Mersey River, Poatina and Maydena localities, the apparent exceptions being the Bronte, King William Saddle and Poatina drill hole No. 5021 localities. The apparent lack of liquid hydrocarbons in these areas may be the result of the ratio of sapropelic to humic kerogen, or the result of the samples being overmature.

Hunt (1979) observed that the yield of hydrocarbons per volume of sediments is higher in basins of high heat flow. The oil present in the Woody Island Siltstone Formation Correlate at Maydena appears to have been generated in the temperature interval 80-90°C.

An interesting feature of the geothermal gradients shown in Figure 1 concerns the gradient across the Wynyard Tillite and the Eldon Group, which is very slightly positive to markedly negative; this may be due to the following:

- (i) A high thermal conductivity of the sandstone rich Eldon Group, or,
- (ii) A positive geothermal gradient across the Eldon Group which was cancelled by a negative gradient across the Wynyard Tillite, or,
- (iii) An inflated figure for the thickness of the Eldon Group in the Florentine Valley area, and conversely a deflated figure for the thickness of Eldon Group in the Lune River area. If this interpretation is correct, it would modify the hypothesis advanced concerning hydrocarbon generation (potential) in the Gordon Limestone at Lune River.

8:0 POTENTIAL OIL RESERVOIR ROCKS

8:1 Gordon Sub Group

As mentioned previously, the Gordon Limestone is generally fine grained (micritic), a feature which would have assisted diagenetic calcite cementation so that the present intergranular porosity would be  $\ll 2\%$ . As the micrite facies of the Gordon Limestone seldom contain  $< 2\%$  of acid insoluble residue (AIR), some compaction would have occurred.

Impure limestone (eg. Karmberg) with an estimated composition of  $\ll 85\% \text{ CaCO}_3$  and 5-10% AIR (clay minerals, chert) would experience fluid losses through compaction, thus enabling primary migration mechanisms to operate. Other evidence of inferred migration mechanisms comes from those sections of Gordon Limestone which have been dolomitised. Potential reservoirs in the Gordon Limestone appear limited to coral reefs, and those areas of secondary (granular) dolomite. Coral gardens were common from Blackriveran to Cincinnattian time, but no authentic bioherms have yet been found.

The presence of an Ordovician continental slope has been inferred east of Flowery Gully, where Mathinna Group rocks overlie Gordon Limestone; more recently (C.F. Burrett, pers.comm.) the discovery of a deep water facies of the Gordon Limestone at Surprise Bay, has led to the recognition of a continental slope in the south of the state.

The base of the Gordon Limestone is strongly diachronous, and the Ordovician sea is inferred to have advanced over the Tyennan Geanticline in a generally westward direction. C.F. Currett (pers.comm.) postulates that the coralline facies at the top of the Benjamin Limestone in the florentine Valley was a back reef, with a yet to be discovered fore reef to the east; M.R. Banks (pers.comm.) believes the Ordovician sea contained several islands (e.g. Vale of Rasselas, Glenorchy). Thus a model may be envisaged whereby the Ordovician continental slope extended south from Flowery Gully along what is now the Tamar Fracture System (itself activated in Carboniferous time) and south west to Surprise Bay.

Deposition of Gordon Limestone west of this line would have been under shallow water platform conditions, possibly with fore reefs which would have migrated west (landward) in the westward transgressing sea.

Secondary dolomites are known from several places in the Gordon Limestone; at Lune River secondary dolomite was formed by the action of hypersaline brines which originated in supratidal facies limestone during diagenesis; this dolomite is porous and vuggy, but no details of its intergranular porosity are known.

#### 8:2 Eldon Group

This group consists of alternating sequences of sandstone and siltstone with minor limestone; it has a high sand : shale ratio and should be viewed as hosting potential reservoirs. No data on its intergranular porosity is available at present.

#### 8:3 Parmeener Super Group

Mention has already been made of the smectitic nature of some of the clays in this group; the dehydration of smectite to illite provides extra pore water for migration mechanisms. Possible reservoir rocks include:-

- (i) Lower Marine Sequence - Darlington Limestone and the basal conglomerates.
- (ii) Lower Freshwater Sequence - Mersey Coal Measures.
- (iii) Upper Marine Sequence - Malbina Formation, Risdon Sandstone.
- (iv) Upper Freshwater Sequence - Cygnet Coal Measures, Ross Sandstone.

No data on intergranular porosities is known; the Woody Island Siltstone correlate at Maydena may be a reservoir as a function of its microfracture porosity.

APPENDIX

GEOHERMAL ENERGY

The use of geothermal energy is relatively modern, and it differs from conventional energy sources (fossil fuels, uranium) in that it may be directly utilized without prior combustion or fission.

Three types of geothermal systems are commercially operative or feasible, namely vapour dominated systems, and liquid dominated systems of both high and low enthalpy (natural circulation).

Extraction of geothermal energy from hot, dry granite is currently being investigated at Fenton Hill, New Mexico, U.S.A.; the technique used involves drilling to depths where the temperature is  $>160^{\circ}\text{C}$ , and then creating an artificial fracture system through which water is circulated, and the thermal energy recovered by heat exchangers, or by using the steam produced as a result of the method.

A similar program of research is being undertaken on granites in Cornwall, U.K., which have heat productivities of similar and lesser magnitude to the five areas of hot dry geothermal energy outlined by Collins et al (1981, in press) in Tasmania.

The Tasmanian Government has approved the drilling of a geothermal test hole at Coles Bay, but is unable to provide finance for the program.

It is apparent that in an increasingly energy short world alternative energy forms will assume greater significance. On present indications, the geothermal energy available in Tasmania is comparable and possibly superior to that elsewhere, and its future utilization should be given serious consideration.

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1.0 INTRODUCTION

Dames & Moore was commissioned by Victor Petroleum & Resources Ltd. on April 24th, 1981, to conduct a prefeasibility study and coal valuation of the Woodbury Coal Project, Tasmania. In order to conduct the study, Dames & Moore was provided with the following material:

- "Tasmanian Exploration Licence 31/80 - Renewal & Progress Report to May 21st, 1981" E. Eshuys & J.D. Smith
- "Report on the Department of Mines Coal Exploration Programme at Fingal, Vol. 1" Tasmania Department of Mines
- Plans of the area under consideration showing Isopach of Seams I & II, Reduced Level of Seam I, II and Lower Dolerite Sill, Overburden Thickness Seam I, Interval Seam I-II and Extent of Dolerite Outcrop
- Geological Cross Sections
- Drill Hole Correlation: Density Log, Gamma Ray Log, S.P. & R.

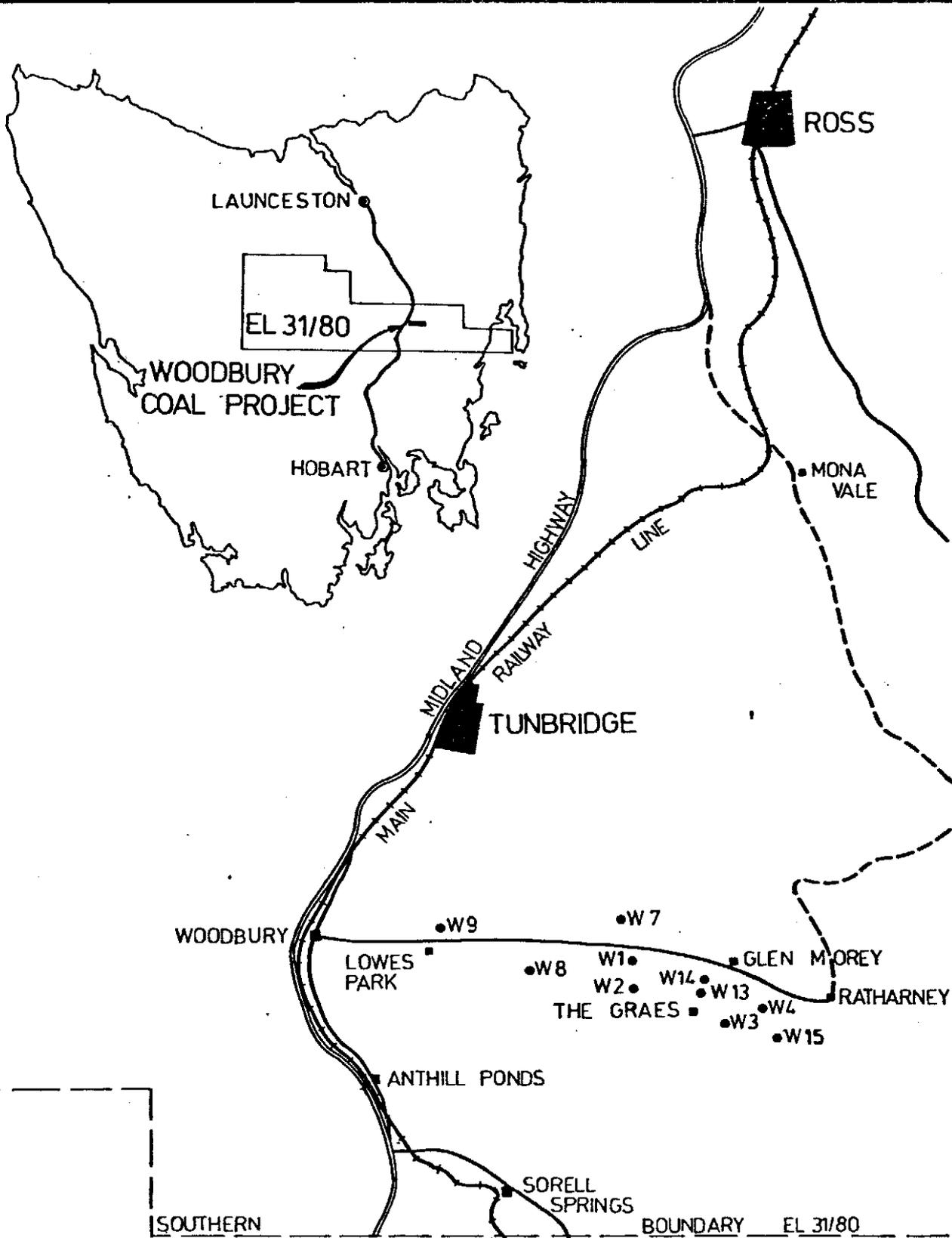
It was agreed that our "Scope of Work" should include:

- Assessment of existing geological information
- Calculation of overburden and coal quantities
- Selection of an economic mining method from a prefeasibility study
- Calculation of an indicative total mining cost per tonne ROM coal
- Assessment of coal recovery and washing costs
- Valuation of in-situ reserves based on assumed transport costs and selling price of coal.

The following parameters were used as a basis for our calculations in this study:

- A nominal 200 working days per year
- A 7 hour x 5 day x 40 week basis
- An open cut mine area with a maximum overburden ratio of 7:1
- An underground mine area with a minimum seam thickness of 1.4 metres
- A yield of 70% of coal containing 20% ash. (A yield percentage of 70% has been assumed on the basis of a range of 73% to 83% yield over 10 years from the Fingal Valley, as reported by the Joint Coal Board in their report "Black Coal in Australia 1979-80".)
- Selection of an economic coal production schedule
- Inclusion of necessary mine infrastructure.

The location of the Woodbury Coal Project is shown in Figure 1.



<b>VICTOR PETROLEUM &amp; RESOURCES LTD</b>	
TITLE:	LOCALITY PLAN
LOCATION:	WOODBURY, TASMANIA
SCALE:	1:120,000
REF.:	
<b>FIGURE 1</b> JOB No. 12445-001-70 DATE: JUNE, 1981 <b>DAMES &amp; MOORE</b>	

## 2.0 GEOLOGICAL ASSESSMENT

### 2.1 General

Geologically the site is situated in the Tasmanian central plateau mass consisting of block faulted and warped Permo Triassic sediments and dolerite. The coal seams occur within a sequence of lithic sandstones and silty mudstone of the freshwater Triassic coal measures. Igneous activity of Jurassic age resulted in the injection of massive sills of dolerite into the sediments. The dips of the sediments are variable from approximately horizontal to around 3°. The dolerite occurs as a capping on the main topographic highs and as secondary intrusions within the coal measures. It is not known whether the dolerite outcropping on the black Tier range is sill-like or dyke-like.

### 2.2 Coal Seams

Two significant coal seams have been intersected; the upper seam (Seam I), up to 2.8m thick, and lower seam (Seam II), up to 1.3m thick. To date there is no available evidence for faulting of the coal seams. There is no reliable coal quality data available at present. The boreholes were open hole drilled, and subsequently logged by wireline geophysical techniques. In general, Seam I has a sandstone roof and a mudstone floor, while Seam II has a mudstone roof and floor.

Triassic coal in Tasmania exhibits large variations in the thickness of included bands, and in roof materials, and faulting and rolling is also prevalent. Triassic coal in Tasmania is commonly high in ash content (18-24%), low in sulphur (0.3-0.5%), has a low calorific value, and is suitable for only steam raising and domestic use.

### 2.3 Coal Reserve Assumptions

Because there is no Tasmanian code for calculating and reporting coal reserves, the code adopted by the Geological Survey of Queensland has been used in this report. All reserves stated in this report are in-situ second class indicated reserves, and are reported in tonnes. The density of each of the two seams is assumed to be 1.6 tonnes per cubic metre t/m<sup>3</sup>. In general, influence of the boreholes has been extended to approximately 1 km.

Figures 2 and 3 are seam isopach maps for Seam I and Seam II respectively. The thickness contours represent the cumulative thickness of the in-situ coal. All high ash bands greater than approximately 300mm thick have not been included in the cumulative thickness. The thicknesses as shown in Table 1 were arrived at by a slightly conservative evaluation by our coal geologist of the logs that were made available to Dames & Moore. The depth of oxidation for Seams I & II is assumed to be 10m. The continuity of Seam I southwards, beneath the dolerite capping is assumed. Overburden thickness isopach and structural contour maps used in this assessment were provided to Dames & Moore by Victor Petroleum & Resources Ltd.

TABLE 1.

SUMMARY OF INTERSECTED COAL SEAMS

BOREHOLE	CUMULATIVE THICKNESS OF COAL SEAM	
	SEAM I. m.	SEAM II, m.
W1	2.1	0.9
W2	2.7	1.2
W3	2.1	1.3
W4	1.0	0.9
W7	1.9	0.7
W8	2.8	-
W9	-	0.8
W13	1.7	0.9
W14	2.4	-
W15	1.7	1.0

1.86

0.77

Further exploration should be utilized to verify or clarify the assumptions used in this evaluation, and to confirm or upgrade coal seam thickness and continuity.

2.4 Coal Reserves

Seam I has in-situ second class indicated reserves of 32.2 Mt, Figure 2. This includes 5.1 Mt which may be mined at overburden (M<sup>3</sup>) to coal (t) ratios of up to 7:1. The area of this possible open cut is shown in Figure 4. For the open-cut area, the overall strip ratio is approximately 5½:1 to 6:1. Seam I splits into 3 seams in the region of borehole W1.

Seam II has in-situ second class indicated reserves of 21.6 Mt, Figure 3. However, only 5.9 Mt of this is situated where the seam is greater than 1.2m in thickness. At present there is insufficient data available on the depth of oxidation, subcrop location, thickness and lateral extent of Seam II, to indicate an area possibly suitable for open cut mining. (For example, if the depth of oxidation is 10m, and the seam is less than 0.9m thick, then the overburden strip ratio is poorer than 7:1).

TABLE 2.  
COAL RESERVES \*

Coal Seam	In-situ Reserves t x 10 <sup>6</sup>	Potential Mining Reserves	
		Open Cut t x 10 <sup>6</sup>	Underground t x 10 <sup>6</sup>
Seam I	32.2	5.1	27.1
Seam II	21.6	-	-
TOTAL	53.8	5.1	27.1

\* in-situ second class indicated reserves

3.0 SELECTION OF MINING AREA & DEVELOPMENT

3.1 Open Cut Mining

For this prefeasibility study, an open cut mining area was selected on the basis of a maximum overburden ratio of 7:1 (i.e. overburden (m<sup>3</sup>) to in-situ tonnes of coal), and the limit of oxidation of the coal seam. Due to the limited geological information available, the limit of oxidation of the coal seam was assumed to be along the 10m overburden thickness contour line. An area for the open cut mining of Seam I is shown in Figure 4. On the information available, the mining of Seam II by the open cut method is not considered economically feasible, due to the excessive overburden ratios in both a single and double seam operation.

The open cut mining quantities are as follows:-

TABLE 3.

	Overburden m <sup>3</sup>	Coal t
In-situ Quantities	29,000,000	5,100,000
Mining Losses @ 10%		510,000
O/C Mining Quantities	29,318,750	4,590,000
Saleable Coal @ 70% Yield		3,213,000

On the basis of the quantities as shown above, an open cut mine development programme should be considered to produce 320,000 tonnes of clean coal, over a nominal mine life of 10 years.

*pa*

3.2 Underground Mining

In the case of an underground mining operation, a minimum seam thickness of 1.4m was selected as an economic limit for consideration. In the underground mining of Seam I, the remainder of the seam can be mined by underground methods, after the initial access is provided by the open cut mining operation. Seam II can be mined by underground methods by the provision of additional access from the Seam I underground operation to Seam II. On the information available, and the drilling to date, drill holes W2 & W3 indicate increasing thickness of Seam II (1.2m & 1.3m respectively), with increasing cover of the seam.

With the limited information available on Seam II, it is considered that the viability of mining Seam II should be deferred until further drilling has been carried out, and a more accurate determination of seam thickness, so that an economic analysis can be carried out on the viability of mining Seam II by underground methods.

The underground mining quantities are as follows:-

TABLE 4.

	Seam I t	Seam II t
In-situ Quantities	32,200,000	21,600,000
Quantity available for U/G Mining	27,100,000	-
Mining Losses @ 20%	5,420,000	-
U/G Mining Quantities	21,680,000	-
Saleable Coal @ 70% Yield	15,176,000	-

Thus, an underground mine development can be phased in to supplement the open cut operation at any point in time during its progress to supply new sales contracts. The total saleable coal available from an underground mining operation is 15,176,000 tonnes, and the development of the mine is considered at the rate of 750,000 tonnes of clean coal over a nominal mine life of 20 years.

4.0 OPEN CUT MINING

4.1 Mine Plan

On examination of the open cut mining area, and with reference to the mine life, layout of the area and limited availability of electric power supply, a large hydraulic shovel and 170T rear dump trucks have been selected as the most economic method of overburden removal. The proposed open cut mining area is an elongated strip along the subcrop of Seam I. The use of a hydraulic shovel would also allow for a more flexible operation over the 5 kilometre length of the open cut mine area, without the problems and cost associated with electric reticulation. The shovel and truck combination would also provide a flexible operation in the selected dumping of overburden and reduced costs in the restoration of the final surface. A large overburden drill is required to obtain the required production so that the overburden can be blasted ahead of the advancing shovel and truck. In this study, a coal drill has been allowed so that the coal can be drilled and blasted, however, with further information on the properties of the coal seam, and analysis of the operation, ripping of the coal seam by dozer may prove to be more economical. A front-end loader fitted with a rock bucket and 85T rear dump trucks were selected for the loading of the coal and its transportation to the coal processing plant. This combination could then be utilised for overburden removal, whenever the overburden removal operation becomes critical.

The operational sequence is as follows:-

4.1.1 Site Clearance

Trees and vegetation are pushed into heaps by bulldozers and burnt.

4.1.2 Topsoil Removal

Topsoil from the mining area is progressively removed, stockpiled and replaced over the restored mine surface. The topsoil is windrowed by a grader or dozed into heaps, and then transported by loader and trucks.

#### 4.1.3 Overburden Drilling & Blasting

The overburden is drilled and blasted by a 171mm to 274mm overburden drill, in advance of the strip required to be mined.

#### 4.1.4 Overburden Removal

The overburden is loaded out in 10m lifts by a hydraulic shovel, and the material is hauled in 170T rear dump trucks via a central access road to the dump area.

#### 4.1.5 Coal Drilling and Blasting

The top of the coal exposed by the shovel is cleared by a rubber tyred dozer prior to drilling and blasting.

#### 4.1.6 Coal Loading and Hauling

Coal is loaded by a large front-end loader into 85T rear dump trucks and transported to the coal processing plant. In the area where the seam is split, the partings can be selectively removed by the front-end loader, and hauled by the 85T trucks to the overburden dump.

#### 4.1.7 Restoration & Site Maintenance

The same sequence of operation continues throughout the life of the mine with the addition of the restoration operation. A bulldozer is used to spread and level the overburden dumps to form the restored surface. As the shovel and trucks advance through the mining area, the restoration proceeds at the same rate, keeping the area being mined, to a minimum.

Haul road maintenance and dust suppression is controlled by a grader and water cart. A 20T crane, 4T forklift, fuel truck and lube truck are utilised for plant maintenance and 200mm high lift pumps for dewatering.

#### 4.2 Major Plant

The plant selected for each mining operation was based on previous on-site experience, and on analysis carried out in previous studies.

A schedule of major plant is shown in Table 5. No actual quotes were obtained, and budget prices supplied in previous quotations were used to estimate indicative capital and operating costs for inclusion in this study.

A summary of equipment and operations is as follows:

Site Clearance	Dozer	included in Restoration & Site Maintenance.
Topsoil Removal	Grader	included in Restoration & Site Maintenance.
O/B Drilling & Blasting	O/B Drills	1 No x 10 yrs x 40 wks x 15 shifts x 7 hrs.
	Shotfirer	1 No x 10 yrs x 40 wks x 5 shifts x 7 hrs.
O/B Removal	Hyd. Shovel	1 No x 10 yrs x 40 wks x 15 shifts x 7 hrs.
	170T Trucks	5 No x 10 yrs x 40 wks x 15 shifts x 7 hrs.
Coal Drilling & Blasting	R.T. Dozer	1 No x 10 yrs x 40 wks x 15 shifts x 7 hrs.
	Coal Drill	1 No x 10 yrs x 40 wks x 5 shifts x 7 hrs.
Coal Loading & Hauling	9.6m <sup>3</sup> FE Loader	1 No x 10 yrs x 40 wks x 5 shifts x 7 hrs.
	85T Trucks	4 No x 10 yrs x 40 wks x 5 shifts x 7 hrs.
Restoration & Site Mtce.	Dozer	1 No x 10 yrs x 40 wks x 15 shifts x 7 hrs.
	Grader	1 No x 10 yrs x 40 wks x 15 shifts x 7 hrs.
	Water Cart	1 No x 10 yrs x 40 wks x 15 shifts x 7 hrs.
	20T Crane	1 No x 10 yrs x 40 wks.
	4T Forklift	1 No x 10 yrs x 40 wks.
	Ag. Tractor	1 No x 10 yrs x 40 wks.
	Lighting Set	2 No x 10 yrs x 40 wks.
	200mm Pump	2 No x 10 yrs x 40 wks.
	Fuel Truck	1 No x 10 yrs x 40 wks.
Lube Truck	1 No x 10 yrs x 40 wks.	

TABLE 5.

MAJOR PLANT SCHEDULE - OPEN CUT MINE

<u>ITEM</u>	<u>UNIT LIFE</u>	<u>No. Reqd.</u>	<u>UNIT COST \$</u>	<u>TOTAL COST \$</u>	<u>AVAILABILITY</u>
Hyd. Shovel	10 years	1	4,100,000	4,100,000	12 months
170 T O/B Trucks	30,000 hrs.	5	913,000	4,565,000	9 months
Overburden Drills	20,000 hrs.	1	600,000	600,000	12 months
9.6m <sup>3</sup> F.E. Loader	15,000 hrs.	1	672,000	672,000	stock
85 T Rear Dump Trucks	15,000 hrs.	4	480,000	1,920,000	6 months
Coal Drill	20,000 hrs.	1	332,000	332,000	8 months
306 KW Dozer	12,000 hrs.	1	390,000	390,000	2 months
231 KW RT Dozer	12,000 hrs.	1	247,000	247,000	3 months
134 KW Grader	12,000 hrs.	1	210,000	210,000	stock
25,000 Litre Water Cart	15,000 hrs.	1	253,000	253,000	6 months
Lube Truck	15,000 hrs.	1	40,000	40,000	2 months
Fuel Truck	15,000 hrs.	1	40,000	40,000	2 months
Lighting Set	20,000 hrs.	2	30,000	60,000	6 months
200 mm. High Lift Pump	4 years	2	38,000	76,000	8 months
75 mm. High Lift Pump	4 years	-	-	-	1 month
20 T Crane	15,000 hrs.	1	160,000	160,000	2 months
4 T Forklift	15,000 hrs.	1	38,000	38,000	stock
Ag. Tractor	2,000 hrs.	1	7,000	7,000	stock
<b>TOTAL</b>		26		13,710,000	

## 5.0 UNDERGROUND MINING

### 5.1 Mine Plan

On the basis of the relatively shallow depth to the top of Seam I, and the sandstone roof of the seam, the bord and pillar method of mining has been considered to produce the maximum output per man shift. After the main entry is driven, the panels can be blocked out with barrier pillars to protect the entries. The rooms are developed in isolation so that they can be sealed off against fire, or water, or after extraction to avoid ventilation problems. The room is developed by drives, and then coal is extracted on the retreat, leaving small regular pillars for protection if required. Mining is carried out with continuous miners loading directly into shuttle cars. The coal is carried over a short haul by the shuttle cars and emptied into a ratio feeder, prior to transportation by the underground conveyor. Allowance has been made for the inclusion of a breaker in the underground conveyor system. The coal is then transferred to a surface conveyor for transportation direct to the coal processing plant.

The indicative capital and operating costs are based on an existing underground operation in Tasmania, on a 15 shifts per week basis. With the limited information available on the geology of the strata and the coal seam, average conditions have been assumed, and no allowance has been made for water problems.

### 5.2 Major Plant

The plant selected for the underground mining operation is based on a previous study of a mine with a similar production. A schedule of major plant is shown in Table 6 below:

TABLE 6

MAJOR PLANT SCHEDULE - UNDERGROUND MINE

ITEM	No. REQ	UNIT COST \$	TOTAL COST \$	AVAILABILITY
Continuous Miner	6	550,000	3,300,000	6 months
10-12t Shuttle Cars	10	200,000	2,000,000	6 months
Ratio Feeders	5	140,000	700,000	5 months
1070mm V/6 Conveyor	4	230,000	920,000	3 months
1320mm Trunk Conveyor	1	500,000	500,000	3 months
V/6 Vehicles	4	80,000	320,000	6 months
U/6 Elec Equipment	4	145,000	580,000	4 months
Misc Equip & Safety Gear	1	590,000	590,000	5 months
Surface Elec Equipment	1	250,000	250,000	4 months
Ventilation Equipment	1	1,100,000	1,100,000	4 months
1320mm Surface Conveyor	1	790,000	790,000	3 months
Stockpile Facilities	1	1,330,000	1,330,000	6 months
TOTAL	39		12,380,000	

## 6.0 MINE INFRASTRUCTURE

### 6.1 Open Cut Site Facilities

The Open Cut Site Facilities to be established on the site consist of an office, bathroom, workshop, store and associated facilities. Both the Site Facilities and the Coal Processing Plant have been considered on the basis of commencing operations with the Open Cut Mine to provide access to the Underground Mine Operation. No actual quotes were obtained for this project. However, costs of buildings and maintenance items etc. supplied in previous quotations were used to estimate indicative costs of the requirements for inclusion in this study. In the case of the Underground Mining operation, allowance has been made for the additional facilities required over and above the established facilities of the Open Cut Mining operation.

### 6.2 Coal Haulage & Preparation

The cost of transport of the coal from the mine to a coal receival area has been included in the mining operation. No detailed study was carried out on the route or the cost of the Coal Haulage Road, and a detailed engineering study would be required to finalise the haul road layout and construction requirements. The raw coal is then transported by conveyor to the coal processing plant. After the coal is processed, it is transported either to a stockpile area, or direct to a train loading bin.

It is envisaged that the coal processing plant should be designed for the initial open cut operation with provision for additional units to be added to the plant for the underground operation.

### 6.3 Coal Transportation

For the purposes of a valuation of the coal at Woodbury, the small domestic market within Tasmania has not been considered, and allowance has been made for the transportation of coal from the site to Bell Bay by rail for export.

In discussions with representatives of the Australian National Railways, it was indicated that rolling stock was already available, and that there were no major problems in the transportation of coal from Woodbury to Bell Bay.

Although the rail haulage distance from Woodbury to Hobart is shorter, there are restrictions caused by track capacity, grades, curves and bridge design loads. In considering the restrictions, and the extra shipping costs to Hobart and return, Bell Bay was adopted as the export location.

In the transportation of coal from the site at Woodbury to Bell Bay, the cost has been included for the construction of a spur off the Main Railway Line, and the provision of a loop at the site for an efficient loading operation. The Australian National Railways indicated that upgrading of a small section of the line at Conara Junction would be required, and that they would undertake the construction.

In a meeting with the Port of Launceston Authority, the feasibility of exporting coal from Bell Bay was indicated. At present, facilities are available for ships of up to 80,000 DWT capacity, and up to 100,000 DWT capacity could be available with some dredging of the port. A coal stockpile area is available, and a more suitable location could be constructed on an area to be reclaimed.

7.0 SUMMARY OF COSTS

A Summary of our estimate for direct and indirect costs for the open cut and underground mining operations is shown in Tables 7 & 8 respectively. These costs include depreciation of major plant, but do not include any allowance for capital cost, finance charges for major plant purchase, or operating capital. The costs were calculated on a June 1981 basis. The total Capital Expenditure and Operating Costs for both operations are shown below. The Capital Expenditure allowed for the Underground Mine is on the basis of upgrading the facilities of an established Open Cut Mine.

TABLE 9.

CAPITAL EXPENDITURE - O/C & U/G MINE

	<u>Open Cut Mine</u>	<u>Underground Mine</u>
	\$	\$
Major Plant Purchase	13,710,000	12,380,000
Staff Housing	300,000	200,000
Buildings & Workshop	350,000	100,000
Coal Preparation Plant	4,500,000	4,000,000
Rail Spur & Loop	1,200,000	-
<b>TOTAL CAPITAL EXPENDITURE</b>	<b>20,060,000</b>	<b>16,680,000</b>

TABLE 10.

OPERATING COST - O/C & U/G MINE

	<u>Open Cut Mine</u>	<u>Underground Mine</u>
	\$	\$
Direct & Indirect Costs	<del>15-07</del>	16-90
Washery Cost	2-50	2-50
Washery Yield Allowance @ 70%	6-46	7-24
Rail Transportation Cost	7-00	7-00
Port Charges	1-00 <i>including loading</i>	1-00
Financial Charges & Insurance	3-00	2-00
<b>TOTAL OPERATING COST</b>	<b>35-03</b>	<b>36-64</b>

TABLE 7.

ESTIMATE OF COSTS - OPEN CUT MINE

<u>DESCRIPTION</u>	<u>QUANTITY</u>	<u>UNIT</u>	<u>RATE</u> \$/tonne <i>coal.</i>	<u>AMOUNT</u> \$
<u>DIRECT COSTS</u>				
Shovel & Truck O/B Removal	4,590,000	tonne	6-57	30,156,300
Drill Overburden	4,590,000	tonne	1-07	4,911,300
Blast Overburden	4,590,000	tonne	1-45	6,655,500
Coal Drilling & Blasting	4,590,000	tonne	0-37	1,698,300
Coal Loading & Hauling	4,590,000	tonne	1-39	6,380,100
General Site Maintenance (including site clearance & restoration)	4,590,000	tonne	2-94	13,494,600
<b>TOTAL DIRECT COST</b>	<b>4,590,000</b>	<b>tonne</b>	<b>13-79</b>	<b>63,296,100</b>
<u>INDIRECT COSTS</u>				
Admin. & Supv. Labour	10	years	528,000	5,280,000
Site Vehicles	10	years	40,000	400,000
Workshop Maintenance	10	years	10,000	100,000
Office/Bathhouse Mtce.	10	years	10,000	100,000
<b>TOTAL INDIRECT COST</b>	<b>4,590,000</b>	<b>tonne</b>	<b>1-28</b>	<b>5,880,000</b>
<b>TOTAL COST</b>	<b>4,590,000</b>	<b>tonne</b>	<b>15-07</b>	<b>69,176,100</b>

TABLE 8.

ESTIMATE OF COSTS - UNDERGROUND MINE

<u>DESCRIPTION</u>	<u>QUANTITY</u>	<u>UNIT</u>	<u>RATE</u> \$/tonne	<u>AMOUNT</u> \$
<u>DIRECT COSTS</u>				
Labour	21,680,000	tonne	8-37	181,461,600
Roof Supports	21,680,000	tonne	1-68	36,422,400
Plant Repair	21,680,000	tonne	0-45	9,756,000
Power Cost	21,680,000	tonne	0-54	11,707,200
Plant Depreciation	21,680,000	tonne	1-46	31,652,800
Maintenance Material	21,680,000	tonne	2-53	54,850,400
Mine Stores	21,680,000	tonne	1-49	32,303,200
TOTAL DIRECT COST	21,680,000	tonne	16-52	358,153,600
<u>INDIRECT COSTS</u>				
Administration	20	years	350,000	7,000,000
Site Vehicles	20	years	40,000	800,000
Workshop Maintenance	20	years	10,000	200,000
Office/Stores Maintenance	20	years	10,000	200,000
TOTAL INDIRECT COST	21,680,000	tonne	0-38	8,200,000
TOTAL COST	21,680,000	tonne	16-90	366,353,600

8.0 POSSIBLE MARKET & COAL VALUATION

The coal produced from Woodbury with its high ash content would be suitable only for steam raising and household use. The markets available to the coal are domestic power generation, domestic industrial use, export to a high ash market, and export to an Australian port, or direct to Japan for blending with low ash coals. In discussions with the Hydro-Electric Commission of Tasmania, it was indicated that there was a potential demand for coal within Tasmania for power generation. The domestic industrial market is understood to be currently fully supplied, but no enquiries were made to confirm this belief, or to investigate future industrial markets. Thus, there is a potential market for the coal within Tasmania, however, because of the uncertainty of supply requirements and potential market price, the coal valuation has been considered on an export basis. Taking into account knowledge of existing sales contracts for coals of different ash contents, and current negotiations, an export price of A\$38-00 FOB Bell Bay has been assumed for use in this study, and the coal valuation is as follows:-

TABLE 11.

COAL VALUATION

	<u>Open Cut Mine</u>	<u>Underground Mine</u>
Export Selling Price/tonne	\$38-00	\$38-00
Total Operating Cost/tonne	\$35-03	\$36-64
Coal Value/tonne	\$ 2-97.	\$ 1-36
Saleable Coal @ 70% Yield	3,213,000 t	15,176,000 t
Coal Value	\$9,542,610	\$20,639,360

## 9.0 CONCLUSIONS

Within Exploration Lease EL/80, a mining area has been defined that contains sufficient coal to sustain an open cut mining operation at a production rate of 320,000 tonnes of clean coal per year, over a nominal 10 years period, and an underground mining operation at a production rate of 750,000 tonnes of clean coal per year, over a nominal 20 year period.

From our study of the operation, this coal can be mined, processed, transported and loaded for export at a total cost of \$35-03/t of clean coal for the open cut mining operation, and \$36-64/t for the underground mining operation.

On the basis of an assumed export price of \$38-00 per tonne, the open cut coal has a valuation of \$9,542,610, and the underground coal has a valuation of \$20,639,360, giving a combined total of \$30,181,970. This valuation is based on 9 (nine) open drill holes, an assumed yield of 70% at 20% ash, and an export selling price of A\$38-00 per tonne FOB Bell Bay.

This prefeasibility study and coal valuation has been conducted with limited drilling information, and assumptions have been made for the coal quality.

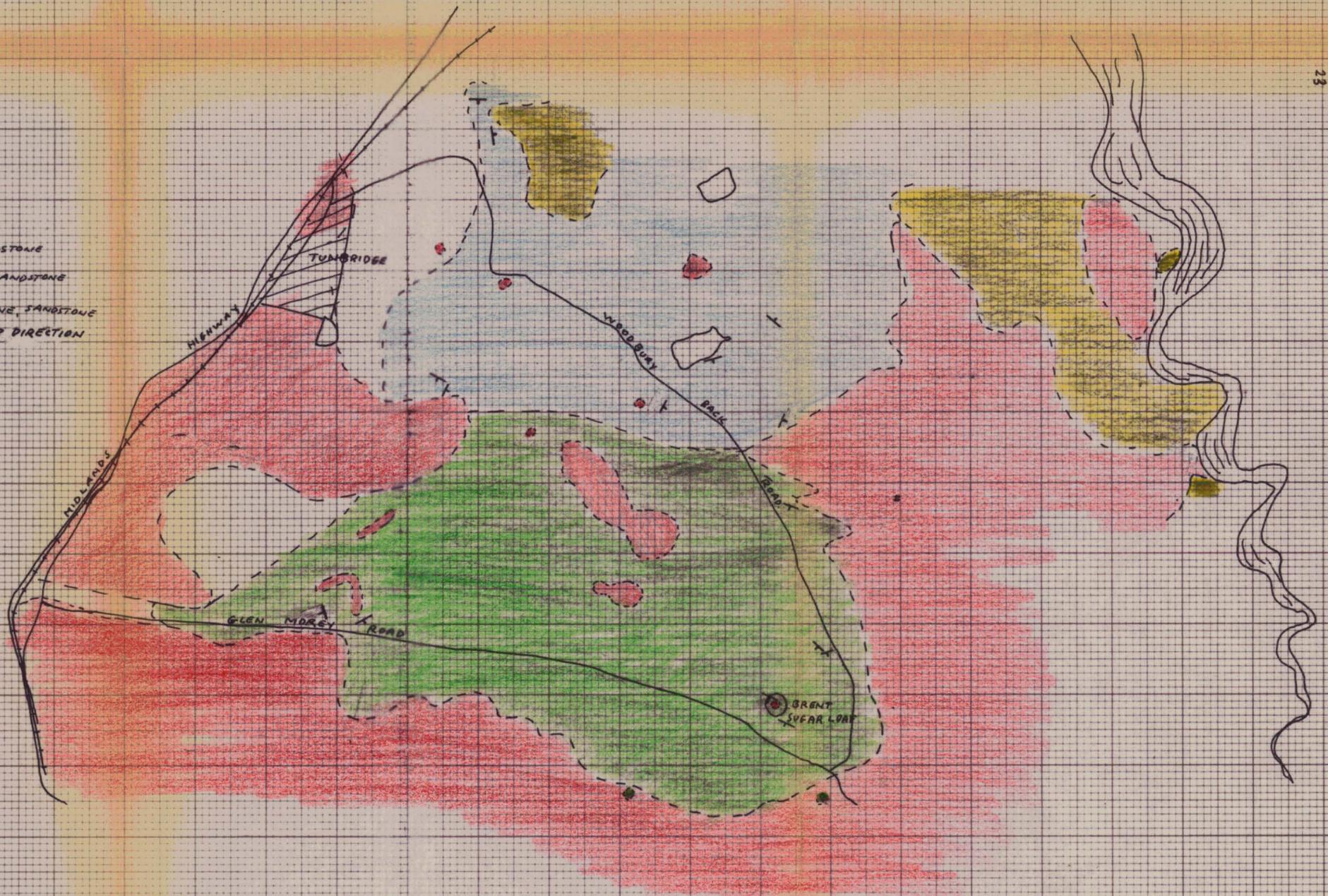
The drilling programme currently being undertaken, and the results from a coal quality analysis are essential for a re-evaluation of this project on a feasibility basis.

It is recommended that further exploration and drilling be carried out to the east and west of the area studied. This exploration could prove additional coal reserves with Open Cut potential, resulting in a selection of plant to give a lower overall cost per tonne of coal for the Open Cut Mining Operation.

For the Underground Mining Operation, further drilling to the south should increase the coal reserves of Seam I and consequently lower the overall cost per tonne. The viability of mining Seam II could also be proven with further investigation and this could lead to a further lowering of the overall cost.

RECONNAISSANCE MAPPING: TUMBRIDGE - MASQUARIE RIVER AREA

- TERTIARY BASALT
- JURASSIC DOLOMITE
- TRIASSIC LITHIC SANDSTONE
- TRIASSIC QUARTZ SANDSTONE
- PERMIAN SILTSTONE SANDSTONE
- STRIKE DIRECTION, DIP DIRECTION



GEOLOGICAL SKETCH MAP No 1  
EL 31/80

RECONNAISSANCE MAPPING - ROSS - MACQUARIE RIVER AREA



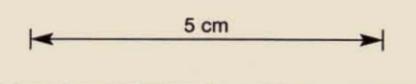
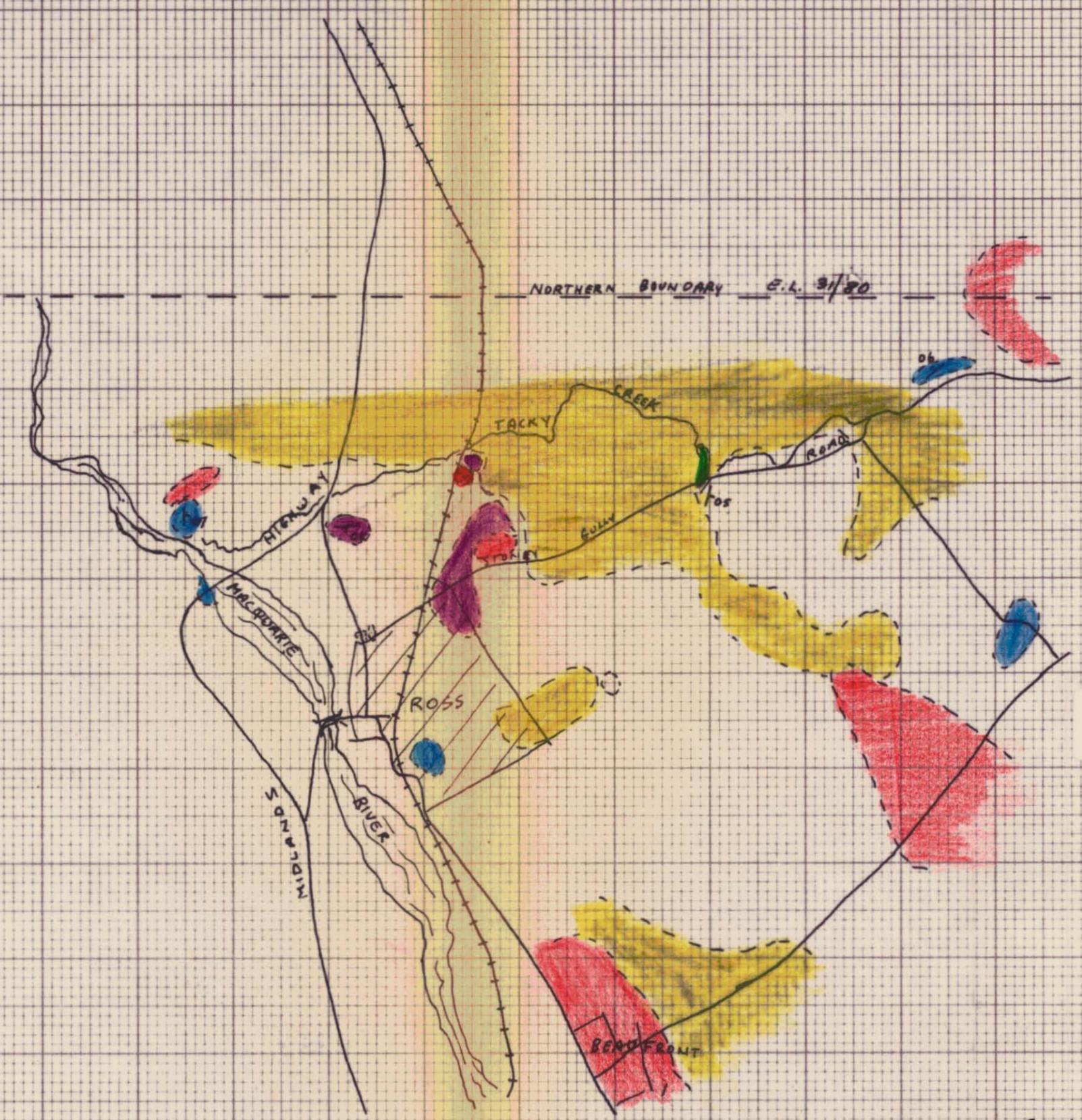
22000'  
1:42,000

RUN  
23

NORTH EAST

T799-208

NORTHERN BOUNDARY E.L. 31/80



- TERTIARY BASALT
  - JURASSIC DOLERITE
  - TRIASSIC LITHIC SANDSTONE
  - TRIASSIC QUARTZ SANDSTONE
  - PERMIAN SILTSTONE, SANDSTONE.
- f<sub>05</sub> STRIKE DIRECTION, DIP ANGLE.

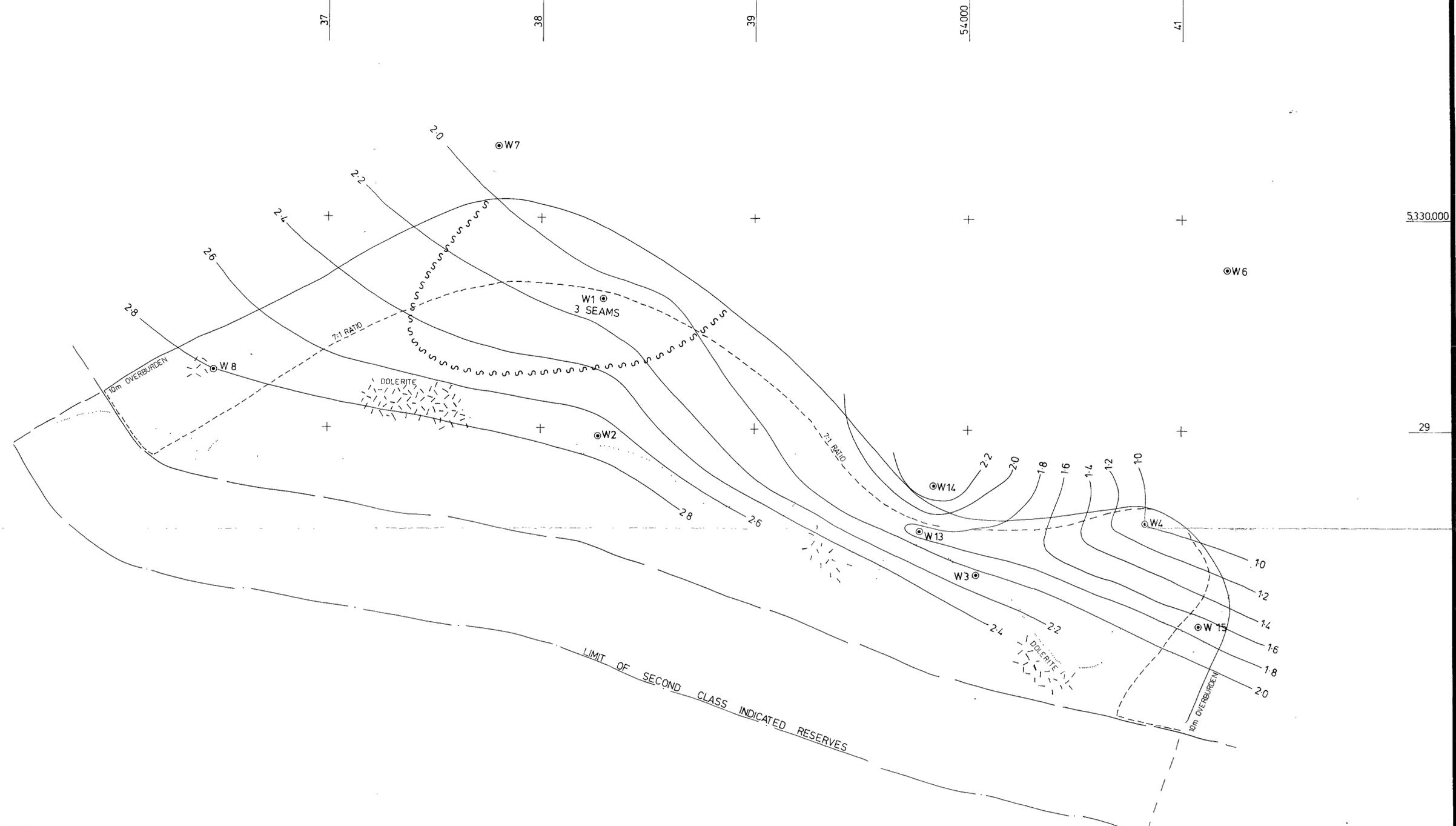
GEOLOGICAL SKETCH MAP NO2  
EL 31/80



WOODBURY COAL PROJECT  
T 798/2444-23 4.25  
X 5-2645  
Scale 1:5000  
Date of photography 30.6.79

5m



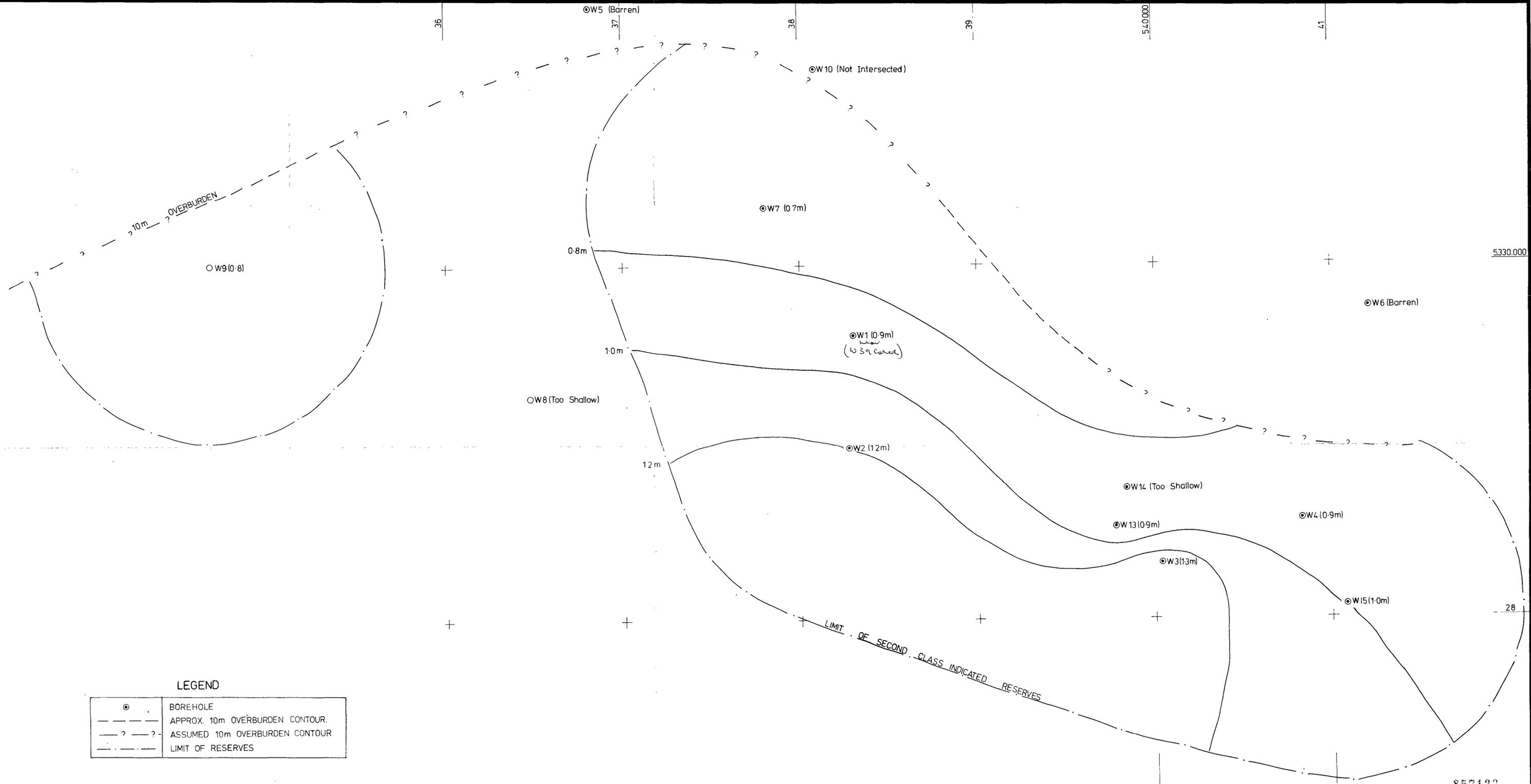


LEGEND

●	BOREHOLE
- - - - -	7:1 OVERBURDEN RATIO CONTOUR LINE
- - - - -	LIMIT OF DOLERITE OUTCROP
10m   - - - - -	10m OVERBURDEN ISOPACH
~~~~~	APPROXIMATE AREA OF SEAM I SPLIT (TO 3 SEAMS)
- - - - -	LIMIT OF RESERVES

857122

<b>VICTOR PETROLEUM &amp; RESOURCES LTD.</b>	
TITLE: SEAM I ISOPACH	FIGURE 2
LOCATION: WOODBURY, TASMANIA	JOB N <sup>o</sup> : 12445-001-70
SCALE: 1:10,000	DATE: JUNE, 1981
REF: 	<b>DAMES &amp; MOORE</b>



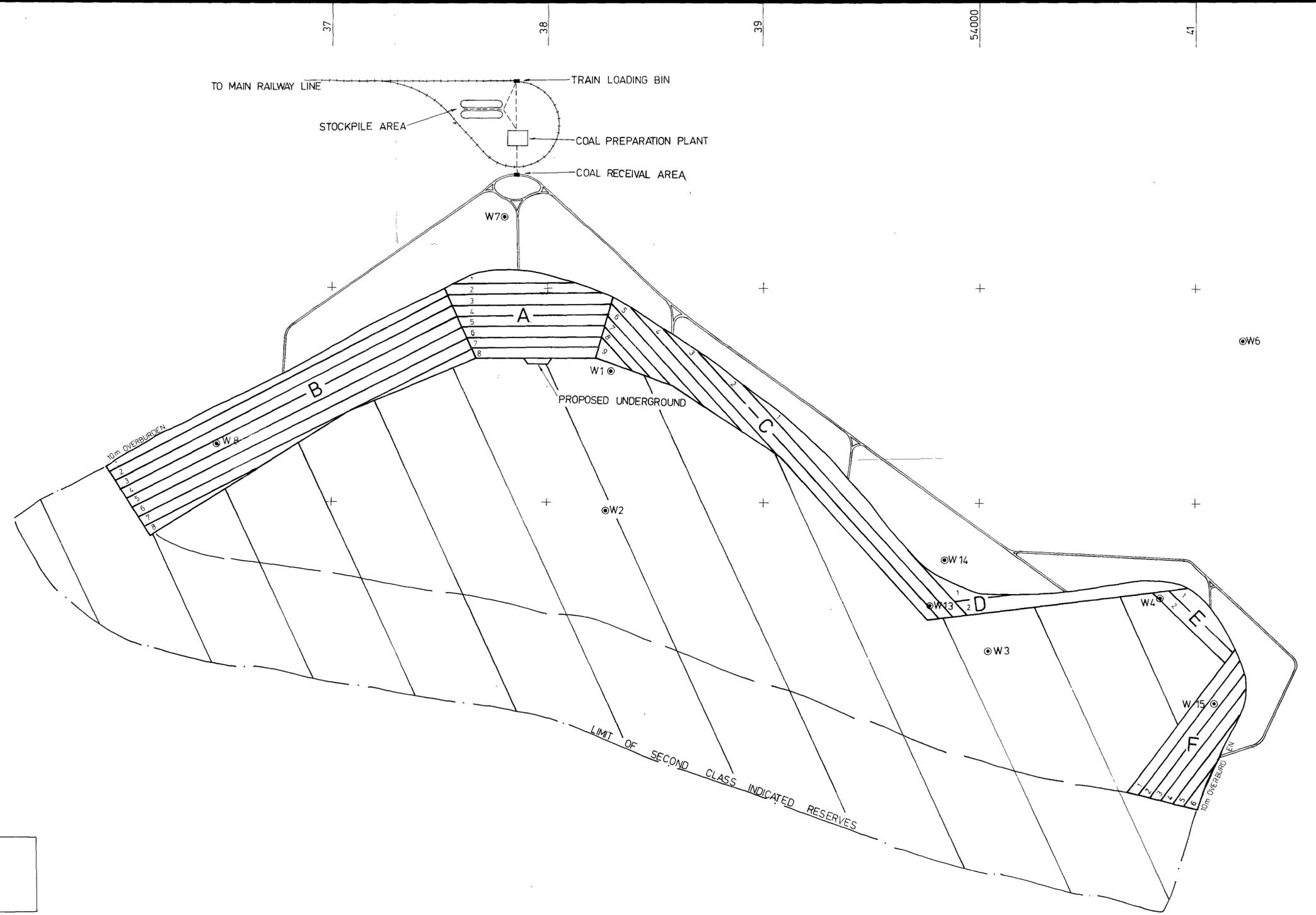
**LEGEND**

⊙	BOREHOLE
-----	APPROX. 10m OVERBURDEN CONTOUR.
.....	ASSUMED 10m OVERBURDEN CONTOUR
- . - . - .	LIMIT OF RESERVES

<b>VICTOR PETROLEUM &amp; RESOURCES LTD.</b>	
TITLE: SEAM II ISOPACH	FIGURE 3
LOCATION: WOODBURY, TASMANIA	JOB NO. 12445-001-70
SCALE: 1:10,000	DATE: JUNE, 1981
REF:	<b>DAMES &amp; MOORE</b>

857123

5330.000



**LEGEND**

●	BOREHOLE
—	10m OVERBURDEN ISOPATCH
- - -	LIMIT OF RESERVES
////	UNDERGROUND MINE AREA

857124

<b>VICTOR PETROLEUM &amp; RESOURCES LTD.</b>	
TITLE: OPEN CUT MINE PLAN	FIGURE 4
LOCATION: WOODBURY, TASMANIA	
SCALE: 1:10,000	JOB NO: 12445-001-70
	DATE: JUNE, 1981
REF:	<b>DAMES &amp; MOORE</b>