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Tasmanite Oil Shale Prospect

By

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TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
SUMMARY AND CONCLUSIONS	2
PREVIOUS WORK - HISTORICAL PERSPECTIVE	5
GENERAL GEOLOGY AND MINERALISATION	7
THE ORE POTENTIAL	11
MINING CONSIDERATIONS	15
BITUMEN MARKETING	20
PROCESSING	26
BROAD ECONOMIC EVALUATION	28

INTRODUCTION

This report is a broad evaluation of the work done to date on the Tasmanite Oil Shale Prospect in Tasmania.

The evaluation has been done as a result of a request from CRA Exploration Pty Ltd.

A study has been made of the all relevant data and detailed discussions have been held with T. Dickson and I. Clementson of CRAE: D. Cain and B. Roberts of the Energy Development Group; and F. Baker and R. Kyne of CRA Technology.

As a result of this, the data and parameters used in this evaluation have been established.

Broad economic evaluations have been done separately on a possible opencut operation and an underground operation.

- 2 -

SUMMARY AND CONCLUSIONS

- 1 The estimated capital and operating costs of producing a nominal 50,000 tpy bitumen from an opencut and underground operation is given below, together with the current selling price for bitumen in Tasmania and Victoria.

	<u>Open Cut</u>	<u>Underground</u>
Estimated capital and operating cost (per tonne bitumen product)	\$344/t	\$433/t
Current bitumen price in Tasmania*	\$269/t bitumen	
Current bitumen price in Victoria**	\$263/t bitumen	

* Probably subsidised by Tasmanian Government

** Ex BP refinery, Westernport

- 2 Although capital and operating cost estimates are dependent upon product specification (for which none presently exist), neither an open cut or underground operation provides a basis for an economic operation with the parameters used.
- 3 Any utilisation of the Tasmanite bitumen on roads would be dependent on the development of a specification for its use as a binder. Quality requirements have now reached the stage that it takes nearly three years to gain acceptance of a new bitumen from the State Government road making authorities. (B. Roberts, 1982)

With the present world oil glut, such a three year time lag would most probably mean a widening of the gap between bitumen production costs and bitumen selling price, even more so than those shown above.

- 4 The study shows that, irrespective of capital and operating cost estimates, the project is sensitive to market penetration.

The current bitumen consumption in Tasmania is of the order of 10,000-20,000 tpy. With a nominal production capacity of 50,000 tpy, and assuming 100% market penetration in Tasmania (highly unlikely!), approximately 30,000-40,000 tpy bitumen must be transported by sea tanker and sold on the Victorian market in direct competition with the oil refineries. Sales of this order would mean a market penetration of some 30-40% in Victoria, a highly unlikely event considering the very lucrative nature of the bitumen market.

To sell bitumen on the Victorian market (and probably also on the Tasmanian market), would require assurance that the oil companies (and coke producers and future coal to oil conversion producers) with their by-product/waste-product bitumen, would not adjust their prices to keep out extraneous competition. Such assurance cannot be guaranteed and, in fact, the oil refineries could drop their price down to about \$70/tonne.

- 5 To date, about 40 mt of potentially economic mineralisation has been defined. There is significant potential to increase this figure, but any increase in tonnage would occur below 50 metres from the surface. There is virtually no potential to increase the reserves occurring at shallow depths (less than 20 metres) beyond the current estimate of around 5 mt.
- 6 If the reserves as outlined to date are uneconomic, if the potential to increase the reserves of possible open cut ore is limited, if the bitumen product specification takes three years to gain acceptance, and if the project is sensitive to market penetration and possible price cutting by the oil refineries, then the reality of continued expenditure (whether for drilling or further test work on the oil shale) on the Tasmanite oil shale must be in question.

- 4 -

- 7 Alternative uses for the Tasmanite oil shale appear to be limited. Other oil based products are reported to have been made in the past, but their cost would be on top of the already high processing costs as their production in quantity would require cracking of the bitumen. Petrols derived from oil shale were reported to have high sulphur contents.

Using the kerogens as a feed stock for a biotechnology process to produce protein for animal consumption has been discussed, but appears to be unlikely (and uneconomic) based on British Petroleum's protein from oil experience.

PREVIOUS WORK - HISTORICAL PERSPECTIVEExploration

The Tasmanite oil shale has been known since the late 19th century and was worked from around 1910 to 1934 in the Railton - Latrobe area. During this time extensive exploration was conducted by the operating mines, lease holders and the Tasmanian Mines Department.

The Tasmanian Mines Department resumed exploration in 1940/41 with a drilling programme close to one of the old mines. Between 1940/41 and 1973 no exploration was carried out until Endeavour Resources took over the area in 1974. During 1975 Endeavour Resources conducted a drilling programme to assess the potential for open cut oil shales. The drilling program consisted of 46 holes totalling 1,041m in and around the areas where the shale was known to occur at shallow depth.

Oil and Bitumen Production

Up to 1935, oil was extracted from the shale by surface retorting, the first small retorts being erected in 1910. By 1931 the largest retort, a nominal 12 tons/day Crozier Retort*, was in operation in the area, but had to cease operation by 1934. The retorts were wood fuelled and gave oil recoveries of about 85%, the remainder being lost in residues and by vapour phase cracking on the hot walls.

*The Crozier retort was a vertical retort with external heating through which the shale passed by gravity. The retort proper was a flat sided metal cylinder with semi-circular ends, surrounded by brickwork constructed to act as flues.

- 6 -

The total amount of crude oil obtained between 1910 and 1934 by surface retorting was approximately 250 000 gallons (1.13 million litres). The oil was refined into a variety of products, and 1932 sales records of the Tasmanite Shale Oil Co. show distribution of 11 693 gallons of refined bitumen - all sold to local government bodies. (F.L. Hunt, A Preliminary Assessment - Tasmanite Oil Shales as a Bitumen Resource, December 24, 1975).

Froth Flotation of Tasmanite

Subsequent to 1932 the Tasmanian Department of Mines undertook research into the feasibility of separating and upgrading the tasmanites by froth flotation. In 1936, laboratory scale work at Launceston (Mason and Walker) showed that an organic flotation concentrate (of kerogen spores) could be prepared and then converted to asphalt. Flotation was very effective as the ash content could be reduced to 8% with spore recoveries up to 92%.

Asphalt was produced by thermal digestion of the flotation concentrate at about 420°C, in a closed vessel to "dissolve" the oil spores into a suspension of bitumen and fine ash.

Several hundred tonnes of shale were processed in a pilot plant to yield a concentrate with an ash content around 23%, this being the most suitable grade for the final purpose which was to produce an asphalt suitable for road making. The produce was used as a road surfacing compound on several test sections in the north of Tasmania.

The results of the pilot plant and field tests confirmed the technical feasibility of the process but the economics were not attractive at the prevailing price of bitumen.

GENERAL GEOLOGY AND MINERALISATION

Geographical Location

The Tasmanite oil shale occurrence is in the Railton-Latrobe district along the north coast of Tasmania approximately 16km south of Devonport.

Regional Geology

The Tasmanite oil shales occur in the marine Spreyton beds of lower Permian age. The oil shale horizon occurs near the base of a thick sequence (up to 150m) of mudstones and siltstones which is in turn overlain by the Mersey coal measures.

Faulting and dolerite intrusion are common in the area resulting in more or less separate "blocks" of Tasmanite oil shale occurring at different elevations - the "blocks" being separated from the neighbouring ones by faults and/or dolerite intrusions.

Distribution of Tasmanite Horizon

The present distribution of the Tasmanite is largely the result of post depositional events - faulting, dolerite intrusion, basalt intrusions/extrusions and erosion.

Appendix 2

Figure 1 shows the distribution of Tasmanite occurrence in EL 4/74. To date at least eight separate areas have been identified.

Nature of the Tasmanite Oil Shale

Properties: The Tasmanite oil shale is a light grey to light brown coloured siltstone rich in the fossil Tasmanities punctatus. This fossil is an amber to red coloured discoidal spore case up to 0.5mm in diameter. The discoidal nature of the spores gives the rock a pronounced foliation making it fissile yet tough to fracture across the foliation.

- 8 -

Attitude/Dip: The oil shale is either horizontal or dips at low angles. The dip in the different areas and even in the same area can vary in direction and amount but generally does not exceed around 1 in 10 (5° - 6°). In places the underlying mudstones project into the lower portion of the seam (as evidenced in the old workings).

} ??
 Discovered by
 CRAE drilling

Thickness: The Tasmanite horizon is up to 2m in thickness but averages around 1.4m (refer Table 1).

The horizon usually consists of three bands -

	<u>Average Thickness</u>
Top band - kerogen rich (Tasmanite spores)	0.6m
Middle band - kerogen poor (generally siltstones)	0.36m
Bottom band - kerogen rich	0.41m ✓

(Note: Results based on CRAE drilling).

Occasionally two bands of kerogen poor material are present.

In general, it can be stated that the Tasmanite horizon is made up of approximately 1m of oil shale (0.6m top band plus 0.41m bottom band) and 0.36m of intervening kerogen poor siltstone. Taken as a whole, the Tasmanite horizon generally has gradational contacts with the surrounding mudstones.

Faulting: Many small and large faults are present. On a large scale, the oil shale is block faulted with vertical displacements in excess of 75m. On a mine scale such large displacements appear to be infrequent, however, smaller displacements of 0.3m to 6m are common (c.f. average oil shale width = 1.4m).

The present drilling density is not sufficient to define even a small percentage of the faults. Close drilling would be required for mine planning purposes.

- 9 -

Intrusion: Dolerite intrusives are common and in many cases are thought to have been intruded along faults. Some of the holes drilled by CRAE were actually abandoned in dolerites and basalts.

Pebbles: Waterworn pebbles of hard rock types such as quartz, quartzite, schist, granite, gabbro, dolerite etc. occur erratically distributed throughout the oil shale horizon. The pebbles/clasts are usually around 6cm in diameter, often 15cm and occasionally 0.75m in diameter. In places, particularly towards the top of the seam, or immediately above it, the pebbles become more concentrated, and the rock mass assumes the nature of a conglomerate (eg. Hole RD81 MR59).

Partings: Partings, along which the shale breaks away, generally occur at the top and bottom of the seam respectively. However, at times the partings may be up to 15cm above or below the top and/or bottom of the oil shale horizon.

Oil Yield: The oil yield on distillation depends upon the kerogen (spore) content in the shale. In the richer parts of the Tasmanite oil shale horizon, kerogen content can be as high as 45% which might yield around 260 litres/tonne. For the poorer parts, kerogen content can be as low as 7% yielding only 20 litres/tonne.

Average oil yield for the bands comprising the oil shale horizon are (using CRAE drilling results only) -

Average Oil Yield, l/t

Top band	225
Middle band	29
Bottom band	159

0.5%

approx. 10%
of the
total
oil shale
content

Totally

incorrectly
Average oil yield
from CRAE drilling
results is 20%.

- 10 -

Overall average oil yield for the total Tasmanite horizon is -

- a) 90-120 l/t according to 1950 report by Tasmanian Department of Mines.
- b) Approximately 143 l/t based on results of CRAE drilling and weighting by resource tonnage for each area (Note: CRAE results are based on significantly less number of samples than those of the Tasmanian Department of Mines).

The above figures make no allowance for possible dilution from the hangingwall or footwall but do incorporate the middle band of low kerogen content.

Preparation and Analysis of Tasmanite Samples

"Tasmanite core intersections were geologically logged and subdivided into sample intervals on the basis of spore content. The core was then sawn into equal halves and one half of each intersection submitted for analysis, the second half being stored at CRAE Burnie offices.

The Australian Mineral Development Laboratories (AMDEL) conducted the analyses. Proximate analyses were carried out on an "as received" and a moisture free basis and the oil yield of the Tasmanite samples was determined by Fischer estimate. The results of these analyses plus a summary of the sample intervals and composite oil yields are given in Appendix 4.

The subdivision of the Tasmanite horizon by spore content is reflected in the analyses, the high oil yields generally reflecting high spore content in upper and lower "rich" zones separated by spore deficient zones which produce little oil."

(Extract from CRAE Report No. 11047 by I.M. Clementson, December 25, 1981).

- 11 -

THE ORE POTENTIALPotentially Economic Mineralisation

The present estimated insitu mineralisation at Railton (EL 4/74) is shown in Table 1. The figures are those calculated by CRAE with verification of the tonnage estimates by the authors.

At best, the estimates can only be regarded as potentially economic mineralisation and merely serve to give an impression of the order of magnitude of the Tasmanite resource of the area.

The total potentially economic mineralisation is in the order of 40Mt of Tasmanite in eight separate deposit locations. Of this 40Mt, a maximum of 4.7Mt (in five separate areas) occurs at depths shallower than 20m metres (refer Table 1).

Of the areas drilled, mineralisation is greatest in Areas I, II and III and accounts for approximately 75% of the total potential mineralisation.

Potential for Additional Ore

The potential resource, as yet not fully tested, may increase the total Tasmanite tonnage to over 70Mt. Potential exists for additional Tasmanite -

- a) North of Area 1 (Saggers Hill) - at depths greater than 50m;
- b) North of Area 2 - at depths greater than 90-100m;
- c) North and West of Area 3 - at depths greater than 50-100m;
- d) North of Area 4 - at depths greater than 50m.

TABLE 1

INSITU POTENTIAL ECONOMIC MINERALISATION AT RAILTON

Area	Average depth to oil shale	Average thickness oil shale	No. holes * intersecting oil shale CRAE Endeavour		Approx W:O ratio	Possible mineralisation		Comments
						< 20m depth	> 20m depth	
I	Variable (6m -> 65m)	1.6m	-	5	3:1 to >40:1	0.5 Mt 0.57	4 Mt	
II	56m	1.7m	5	-	20:1 to >50:1	- ? (0.5)	14 Mt	Most oil shale > 75m deep Southern part of area contains 3 Mt at an average depth of 35m. This deposit is on Crown land
III	70m	1.3m	10	-	55:1	1 Mt 0.7	9 Mt	"The Henry Somerset conservation reserve traverses part of this area. The remainder is owned by A.P.P.M."
IV	> 36m	1.2m	-	-	?			Drill hole failed to penetrate tertiary basalt
V North China flat	15m	1.3m	4	3	12:1	2 Mt 2.2	-	Faulting common Dolerite intrusions common H.T. power line crosses this area which is presently planted with 600mm high pines
V South China flat	6m	1.3m	4	2	5:1	0.7 Mt 0.7	-	A number of houses are sited above the oil shale in this area
V South extension	70m	1.8m	2	1	40:1	- 20.5	3 Mt	Faulting common; extensive drilling required to prove up tonnage
VI	54m	1.2m	1	-	45:1	0.5 Mt	5 Mt	
All areas		1.4m	26	11		4.7Mt (Max)	35 Mt	
						Combined: say, 40 Mt		

* Holes drilled adjacent to each other taken as one hole

TABLE 1 - continued

PROXIMATE ANALYSIS (DRY) - CRAE RESULTS ONLY

Area	No. cored holes	Volatiles %	Fixed carbon %	Ash %	Oil yield L/T
I	-	-	-	-	-
II	3	19.22	1.28	79.5	127
III	5	20.25	0.96	78.8	167
IV	-	-	-	-	-
V North China flat	4	17.42	3.80	79.7	139
V South China flat	4	16.33	1.95	81.7	151
V South extension	-	-	-	-	-
VI	-	-	-	-	-

- 14 -

It is thus evident that potential for additional ore is significant, however, the additional ore is at depths greater than 50m. There is thus virtually no potential to increase those reserves occurring at shallow depths (less than 20m) beyond the present estimates of around 5Mt Tasmanite.

In addition, there appears to be little potential to find significant tonnages of "high grade" (high oil yield) Tasmanite in the area which would substantially increase the average oil yield of the total Tasmanite.

- 15 -

MINING CONSIDERATIONS

Since the Tasmanite oil shale occurs as a horizontal or gently dipping horizon averaging 1.4m in thickness, the problems of mining the oil shale are similar to those encountered when mining horizontal or gently dipping coal seams.

Discussions on alternative mining methods and associated costs will thus be restricted to those applicable to conventional open cut and underground coal mining methods.

For this study, all oil shales at a depth shallower than 20 metres are considered to be suitable for open cut mining. Oil shales at depths greater than 20 metres are considered to be suitable for mining by underground methods.

Factors Affecting Choice of Mining Methods

The following factors are considered to have a significant bearing on the choice of mining method and ease of extraction of the oil shale:

- . Depth of oil shale horizon
- . Faulting
- . Intrusives
- . Presence of pebbles/boulders in the oil shale horizon
- . Dilution

Underground Mining

The following factors will affect and impact on the choice of underground mining methods:

Faulting

Since faulting is common throughout the area, the frequency of faulting and displacement along faults will have a major impact on underground mining.

- 16 -

Small scale faults with displacements up to 50cm may inconvenience the mining of the oil shale if closely spaced. Larger faults will require different mine openings or levels for each faulted block.

The abundance of faults virtually precludes the use of longwall mining techniques.

For mine planning purposes, close spaced drilling would be required to locate the numerous faults.

Intrusives

Like faulting, the presence of intrusives (dolerites, basalts) may have a significant affect on mining, particularly those aspects relating to their irregularity, often unpredictable nature, and hardness.

Pebbles/boulders

The pebbly nature of the oil shale horizon may be critical. Damage to the cutters of a continuous miner is a real possibility and may, in fact, prohibit the use of continuous miners. If continuous miners are used, maintenance costs are likely to be considerably higher (2 times to 3 times) than those for continuous miners used in the coal mines on the east coast of Australia.

Conventional drilling and blasting may have to be used if continuous miners are not applicable or the oil shale is too tough and difficult to break across the grain/foliation (as it is reported to be).

Dilution

Dilution in underground mining may arise from:

- 17 -

- (a) uneven floor and roof - floor heaves etc
- (b) mining next to faults and intrusives
- (c) variable dip of the oil shale horizon -

- 18 -

- (d) selectively mining the upper and lower tasmanite seams and not fully discarding the central "barren" seam
- (e) preferential partings of the oil shale horizon - ie, preferential breaking of the seam up to 15cm above and/or below the bottom of the oil shale horizon.
(Note: This can also result in oil shale losses by preferential partings within the oil shale horizon.)

Opencut Mining

Many of the factors discussed under "Underground mining" will only have a "nuisance" impact on surface mining operations.

The presence of faults and intrusives may necessitate increased flexibility in the pit or pits where several "ore" faces would need to be exposed.

The pebbly nature of the oil shale is unlikely to cause difficulties in a conventional truck and shovel operation.

Excessive dilution and/or possible loss of part of the oil shale horizon is a real possibility in opencut mining. The very thin nature of the oil shale horizon (averaging 1.4m) will inevitably mean whole seam mining, and thus careful monitoring of the base of the overburden and the oil shale horizon.

It is probable that only minor rippable overburden exists and that blasting will be required. This virtually eliminates the possibility of using scrapers as the sole means of overburden removal.

Choice of Mining Methods - Summary

Oil shales less than 20m depth

For oil shales at shallow depth (less than 20m), a conventional truck and shovel operation is the most

- 19 -

appropriate method of mining the oil shales. However, the economics of a viable operation depends on sufficient reserves for a life of say 20 years.

Possible mineralisation in this category defined to date is less than 5 mt (insitu resource, not mineable reserves) with virtually no potential to increase this figure.

For an operation producing say 50,000 tonnes of bitumen per annum, opencut production would need to average around 315,000 tonnes oil shale per year (assuming 6.3 tonne oil shale produces 1 tonne bitumen). For a 20 year mine life, a minimum of 6.5 mt of mineable reserves would be required, whilst for a 30 year mine life, around 10 mt of mineable reserves would be required.

The presently defined possible mineralisation at a depth less than 20m is thus insufficient to support a 20 year operation.

Oil shales greater than 20m depth

For oil shales greater than 20m depth, underground mining methods are the only means of extracting the oil shale since overburden stripping ratios become prohibitive. This means the majority of the presently defined mineralisation is only mineable by underground means.

Depending on the hardness and pebbly nature of the oil shale horizon, either continuous miners or conventional drilling and blasting on a room and pillar method (or the like) would be the most appropriate underground mining method. Longwall and shortwall mining methods are virtually precluded because of the abundance of faults and intrusives.

The present underground mineralisation (some 35 mt greater than 20m depth) is more than sufficient for an operation producing say 50,000 tonnes per annum bitumen over a 20-30

BITUMEN MARKETINGThe Australian Bitumen Market

The following represents abstracts from a memo B.E. Roberts to D.A. Cain on the Australian Bitumen Market (Appendix 1, Feb 8, 1982).

Bitumen is supplied to industrial and roadmaking customers from the oil refineries in each State. Typically, bitumen is hauled by road or rail wagon to the job site or provincial centre. Bitumen is supplied in Tasmania by British Petroleum (BP), which operates a small distillation plant in Hobart (the bitumen is delivered to Hobart by sea tanker in a mixture with diesel fuel from BP's Westernport or Kwinana refineries and the diesel fuel is distilled from the bitumen.)

The Australian bitumen consumption in 1979-80 was approximately 500,000 tonnes, however the tight supply of government funds has reduced demand by about 20% (to approximately 400,000 tpa).

Recent bitument consumption in New South Wales, Victoria, Tasmania and South Australia are given below.

Bitumen consumption (tonnes)

<u>State</u>	<u>April 1981</u>	<u>July 1981</u>	<u>Sept 1981</u>	<u>Oct 1981</u>
NSW	15477	14610	9788	9890
Victoria	16812	4895	7666	8143
Sth Aust	6121	1577	2311	3238
Tasmania	1046	889	709	1144

- 21 -

The approximate annual consumption for the four States is as follows:

	<u>Approximate annual consumption (tonnes)</u>
New South Wales	150,000
Victoria	110,000
South Australia	40,000
Tasmania	10,000*

* A contact in Mobil separately advised that the Tasmanian consumption is approximately 16-17,000 tpa.

Bitumen is produced from Middle East crude oil vacuum residues. These crude oils are imported to make up the gap between Australia's consumption and indigenous crude oil production as well as for lube oil production. Current imports of Middle East crude contain in excess of 800,000 tpa of potential bitumen. Only sufficient bitumen is extracted from the vacuum residues to satisfy the market consumption, the remainder being left as a fuel oil blendstock.

Bitumen is highly viscous and has a very high sulphur content. Therefore, it must be "cut-back" with a light oil (typically diesel fuel) before it is suitable for sale as high sulphur fuel oil. Typically, 50-60% diesel fuel must be blended with bitumen before sale as fuel oil. The blending of diesel fuel into fuel oil represents a large debit to the refiners, as fuel oil is worth approximately A\$200/tonne versus diesel fuel at A\$300/tonne. Consequently, sales of bitumen represent a lucrative business for the refiners; a business that they would take strong measures to protect. These measures would most probably involve price cutting, which the refiners will be able to justify, based on the low alternative value of bitumen (approximately A\$70/tonne fob if 55% diesel fuel is required).

Custom in Distribution of Bitumen

Much of the following is taken from a report by F L Hunt ("A Preliminary Assessment - Tasmanite Oil Shales as a Bitumen Resource", Dec 1975.) Although the market study perhaps relates closer to the Victorian market than the much smaller Tasmanian market, the objective is to develop an appreciation of normal sales procedures and identify aspects of sales which may have significance in cost considerations.

There are aspects of the customary buyer/seller relationship which involve a new supplier in substantial capital and operating costs especially where he seeks contracts for sales in country areas.

The influence on costs are:

1) The seasonal emphasis

Hot laid country road primers or seals are carried out in dry weather, normally summer. The supplier needs to maintain storage facilities out of season, carry the cost of production over the winter months, together with the cost of an organisation to market and deliver the product.

Note: Much of the metropolitan work is not so seasonal, so that the cost of production and delivery is more uniformly spread throughout the year.

2) The distribution procedures

Convention is that the supplier provides the material on the job hot, or provides storage in rail cars which are reheatable and accompanied by reheating units - also supplied by the seller. As an example of the capital cost involved, one 10,000 gal railwagon reheatable by flame tube (oil fired from both ends) is about \$60,000 (1975 costs).

- 23 -

Where the supplier is required to transport bitumen to a CRB depot (Ballarat, Horsham, etc), it is usual to operate steam heated special 50 T VLX railwagons depot to depot.

For distances 80 to 100 miles from Melbourne and beyond, supply by 10,000 gal railcar is preferred because:

- * longer leads are uneconomic for road transport of hot products
- * the reheat unit accompanying the railcar gives the road contractor flexibility
- * the one railcar delivery is likely to be used for a number of jobs over time.

For distances less than 100 miles (say), road transport is used - again, the delivery units are the responsibility of the supplier. The road tankers are usually 3000 to 4000 gals capacity. Supply is direct from the refinery, at very short (usually overnight) notice as construction crews are ready for spraying and weather conditions are satisfactory.

3) Existing transport facilities

Between 1949 and 1955, Mobil constructed sufficient railcars to service South Australia and Victoria. When Shell entered the market, it converted road fuel tankers to suit bitumen supply. BP converted rail oil tankers to suit bitumen, and these same rail tankers are used for the railing of other oil products in the winter season.

There are more rail tankers available than in use, but all are privately owned and not likely to be sold to a market newcomer.

- 24 -

Note: Bitumen supplied for asphalt in the metropolitan area need only be supplied to a hotmix depot, or to storage facilities adjoining such a depot - thus giving a distinct reduction in capital requirements by selecting that aspect of the market.

The Current Position re Testing of Tasmanite Asphalt/Bitumen

Engineers of the CRB Asphalt Division have tested one sample of asphalt produced by Manson and Walker in 1939. Results of the testing were not favourable due to the high ash content (42.5% ash - TMD analysis no. 742552, 3 Oct 1975) and included volatiles which complicated the test procedures. The CRB approach is that no specification can be written about this asphalt at present, however, they are willing to pursue further testing and recognise that new test procedures may need to be evolved for this new material (F L Hunt, 1975).

Any utilisation of Tasmanite bitumen or asphalt on roads would be dependent on the development of a specification for its use as a binder, written in conjunction with the National Association of Australian State Road Authorities (NAASRA) by the relevant State Road Authority. The use of Tasmanite bitumen or asphalt on private streets would be subject to local government control and so be under the same specifications.

"The quality requirement for bitumen has increased substantially over the last 10 years following disastrous results with some bitumens (stories abound of whole freeway sections being stripped and resurfaced due to poor bitumen quality control). Quality requirements have now reached the stage that it takes nearly three years to gain acceptance of a new bitumen from the State Government road making authorities. It is also worth noting that the smaller road makers and industrial customers usually rely on acceptance from these authorities, before they in turn will accept any new product".
(B Roberts, Appendix 1)

- 25 -

The product specification is thus a very important, if not critical, component in an overall evaluation since it controls mining strategy and plant design and hence capital and operating costs.

Implications for the Marketing of Tasmanite Bitumen

At a nominal production capacity of 50,000 tpy bitumen, it is obvious from the above discussion that a maximum of only 10,000-20,000 tpy bitumen could be sold in Tasmania. This makes the highly unlikely assumption that all of Tasmania's consumption is derived from the oil shale, and that BP, for some unknown reasons, stops selling bitumen on the island.

It is thus obvious that a sizeable portion of the total bitumen output (say 40,000-45,000 tpy, assuming 50% market penetration in Tasmania) must be transported by sea tanker and sold on the Victorian market (and/or South Australian and/or NSW market) in direct competition with the oil refineries. Sales of this order would mean a market penetration of some 35%-40% in say Victoria, a highly unlikely event considering the lucrative nature of the bitumen market.

To sell 50,000 tpy bitumen, or even 25,000 tpy bitumen (in Victoria, NSW or South Australia) would require assurance that the oil companies and coke producers (and future coal to oil conversion producers) with their by-product bitumen, would not adjust their prices to keep out extraneous competition. Such assurance cannot be guaranteed!

- 26 -

PROCESSING

The processing of Tasmanite oil shale would be strongly influenced by the method used to recover it. As insitu processing is not applicable, some form of mining will be necessary. Only about 10% of the presently known potentially economic mineralisation could be exploited by open cut mining and it is considered that all extensions to the known reserves would necessitate underground working. It is probable that any modern mining method applied to the Tasmanite beds would have to recover all three bands of kerogens. The middle, low grade, band would severely reduce the overall grade and, in addition, there is the distinct probability of further dilution by material recovered from the hangingwall and footwall.

As there is a marked correlation between kerogen grade (as indicated by oil yield) and specific gravity (S.G.) of the material, it is quite conceivable to consider the application of a heavy media processing stage in order to eliminate the lower grade material. Early work produced the relationship between grade and S.G. shown in Table 2, and while there is no certainty that exactly this correlation would apply to the shales currently being evaluated, it would almost certainly be correct to assume that a similar relationship would apply. It should be possible to conduct heavy media separation at a reasonably coarse size, say after primary crushing to -150mm, and thereby minimise processing costs.

Increased knowledge and improved equipment and reagents might allow better flotation results to be obtained than were achieved in the 1930's testwork, but no substantial improvements should be assumed. The production of an 8% ash concentrate at 93% kerogen recovery would be a useful basis for any study of concentrate processing equipment.

- 27 -

Development work on retorts generally since the production of bitumen in Tasmania ceased would allow more efficient equipment to be built and to operate on a continuous rather than batch basis. Testwork would be necessary to confirm it, but if a heavy media separation process were used to upgrade the feed, it might be possible to use the low grade reject as fuel for at least some of the heating load of the retort.

TABLE 2

Specific gravity of shale	Oil Yield Litres/Tonne
1.71	290.4
1.87	235.0
1.90	202.9
1.94	196.6
1.94	206.4
2.04	160.4
2.12	134.0
2.14	105.5
2.17	122.4
2.25	101.9
2.24	72.4
2.29	73.7
2.48	42.9
2.56	33.5
2.48	28.6
2.65	12.1

BROAD ECONOMIC EVALUATION

For the present broad economic evaluation, it is assumed that a production level of 50,000 tpy bitumen is considered a minimum to gain some form of economies of scale. The figure of 50,000 tpy bitumen is that used by F.L. Hunt (1975). It has not been derived by any optimisation study nor related to a detailed market study. At best, it can be considered an intuitive guess.

At the outset, it must be appreciated that capital and operating costs are highly dependent upon bitumen product specifications. At present, no such specifications exists, hence the figures can only be considered as order of magnitude estimates.

Throughout this study, the conversion factor used to relate tonnes of oil shale mined to bitumen produced is:

Approx 6.3 tonnes oil shale = 1 tonne bitumen product.
(Source: F.L. Hunt, 1975)

The current selling price of bitumen in Tasmania is approximately \$269/tonne. The depot price of bitumen in Melbourne is currently \$263/tonne.

Basic mining parameters assumed are as follows:

Annual production	315,000t oil shale
Production days/year	200 days
Production/day	1,575t oil shale
Shifts/day	2 shifts (underground) 1 shift (opencut)
Hours/shift	8 hours
Waste:Ore ratio	7:1 to 8:1 (opencut only) (say 7.5:1)

- 29 -

Underground Mining Cost Estimates

Mine operating costs: \$30/t oil shale (= \$190/t bitumen)

This figure assumes the use of continuous miners (CM) and is based on costs typical for U/G coal mining operations with such equipment. An additional cost of \$3-\$4/t has been added to cover increased maintenance costs due to the pebbly nature of the oil shale.

Mine capital costs: \$7-\$8 million (= \$28-\$32/t bitumen @ 20% capital recovery factor)

Capital costs include:

- a) \$4m for 4 complete units consisting of continuous miners, shuttle cars, etc. Production rate for each CM is estimated to be a maximum of around 300-350 tonnes/shift, especially considering the narrow nature of the oil shale horizon. One CM would act as a stand-by machine.
- b) \$1.5m for ventilation, conveyors, rubber tired equipment, etc.
- c) \$1.5m-\$2.5m for decline development, portals surface mine facilities, etc.

Opencut Mining Cost Estimates

Mine operating costs: \$1.50-\$2.00/t material (=\$80-\$110/t bitumen).
(W:O ratio 7:1 to 8:1)

These figures assume a drill and blast, truck and shovel operation, working on a one shift basis.

Obviously, the cost per tonne bitumen will vary according to depth to oil shale. Where the oil shale crops out, costs will be significantly less.

Mine capital costs: \$8m-\$10m (=\$32-\$40/t bitumen @ 20% capital recovery factor)

Mine capital costs would include such items as trucks, shovels, loaders, crawler drills, pumps, service vehicles, mine offices, etc. Total tonnes of ore and waste moved would amount to approx 2.7 to 3.0 million tonnes (Waste:Ore = 7.5:1).

Processing Cost Estimates

Process operating costs:

Crushing and flotation: \$8/t oil shale (= \$50/t bitumen)

This cost is based on a typical crushing and flotation operation.

- 31 -

Furnace operation: \$4/t oil shale (= \$25/t bitumen)

This figure is taken from F.L. Hunt's report. The cost is in addition to any benefit derived by using plant generated products for heating.

Process capital costs:

Crushing and flotation: \$4m (= \$16/t bitumen @ 20% capital recovery factor)
(excluding H.M. Plant)

Provisional estimate with no design basis.

Furnace for bitumen melting: \$11m (= \$44/t bitumen @ 20% capital recovery factor)

Estimate provided by B. Roberts.

Transportation and Marketing Cost Estimates

Operating costs:

Transportation: \$50/t bitumen

This figure assumes transportation from mine site to depot in Melbourne.

No operating cost estimates are available for distribution of bitumen locally in Tasmania or regionally in Victoria.

Marketing: = \$2/t bitumen

- 32 -

This figure assumes marketing costs represent approx. 1% of product selling price.

Capital costs:

Transportation: \$1.5m (= \$6/t bitumen @ 20% capital recovery factor)

This figure is at best a guess and would cover the costs of heated tankers, rail wagons, depots, etc.

Summary - Capital and Operating Cost Estimates

Table 3 summarises the estimated capital and operating costs for establishing an integrated bitumen production operation based on the Tasmanite oil shale. The following conclusion can be drawn:

- . At the current selling price for bitumen in Tasmania (\$269/tonne), neither an opencut operation nor an underground operation would be economic. Estimated losses for an opencut operation could amount to \$75/tonne bitumen produced, whilst that for an underground operation could amount to \$164/tonne bitumen produced.
- . Similarly, at the current depot price for bitumen in Melbourne (\$263/tonne), neither operation would be economic. Estimated losses for an open cut operation could be as high as \$81/tonne bitumen, whilst for an underground operation could be as high as \$170/tonne bitumen produced.
- . The largest single cost component in an underground operation is the direct mine operating cost - approx \$190/t bitumen produced.
- . The only significant difference between an opencut and an underground operation is the reduced mine operating costs associated with opencut mining - approx 50% of that for underground mining. All other costs remain essentially the same.
- . Costs of transporting bitumen from mine site to a depot in Melbourne (approx \$50/tonne bitumen) is a major cost component in marketing/selling the product in Victoria. This cost would apply to around 40,000-45,000 tpy bitumen, assuming a 50% market penetration in Tasmania.

TABLE 3

CAPITAL AND OPERATING COST ESTIMATES - SUMMARY

	<u>Opencut mining</u>		<u>Underground mining</u>	
	<u>\$/t oil shale</u>	<u>\$/t bitumen</u>	<u>\$/t oil shale</u>	<u>\$/t bitumen</u>
<u>OPERATING COSTS</u>				
Mine operating cost (W:O = 7.5:1)	\$15	\$95	\$30	\$190
Process operating cost	\$12	\$75	\$12	\$ 75
<u>CAPITAL COST @ 20%</u>	<u>Total - \$m</u>		<u>Total - \$m</u>	
<u>CAPITAL RECOVERY FACTOR</u>				
Mine capital costs	\$8m-\$10m	\$32-\$40	\$7m-\$8m	\$28-\$32
Process capital costs	\$15m	\$60	\$15m	\$60
<u>TRANSPORTATION AND MARKETING COSTS</u>				
Mine site to depot Melb.		\$50		\$50
Transportation capital costs		\$ 6		\$ 6
Marketing costs		\$ 2		\$ 2
<u>ADMINISTRATION COSTS</u>		\$20		\$20
<u>TOTAL</u>		<u>\$ 344</u>		<u>\$ 433</u>



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APPENDIX 1

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ED14.4

8th February, 1982

Memo to: D.A. Cain
From: B.E. Roberts

Copy to: J.T. Walsh

J.T. Walsh
16/2

Australian Bitumen Market

Bitumen is supplied to industrial and roadmaking customers from the oil refineries in each State. Typically, bitumen is hauled by road or rail wagon to the job site or provincial centre. Bitumen is supplied in Tasmania by BP, which operates a small distillation plant in Hobart (the bitumen is delivered to Hobart by sea tanker in a mixture with diesel fuel from BP's Westernport or Kwinana refineries and the diesel fuel is distilled from the bitumen). The Australian suppliers of bitumen are:-

<u>State</u>	<u>Refinery Supply Bitumen</u>
Victoria	. Petroleum Refineries Australia (65% Mobil/35% Esso), Altona . Shell, Geelong . BP, Westernport
New South Wales	. Australian Oil Refining (Caltex/Golden Fleece), Kurnell . Shell, Clyde . Total, Matraville
Queensland	. Amoco, Bulwer Island
Western Australia	. BP, Kwinana
South Australia	. Petroleum Refineries Australia, Pt. Stanvac

The Australian bitumen consumption in 1979-80 was approximately 500,000 tonnes, however the tight supply of government funds has reduced demand by about 20% (to approximately 400,000 tpa).

Recent bitumen consumption in New South Wales, Victoria, Tasmania and South Australia are given below.

<u>Bitumen Consumption (tonnes)</u>				
<u>State</u>	<u>April 1981</u>	<u>July 1981</u>	<u>Sept 1981</u>	<u>Oct 1981</u>
N.S.W.	15477	14610	9788	9890
Victoria	16812	4895	7666	8143
Sth. Aust.	6121	1577	2311	3238
Tasmania	1046	889	709	1144

The total 1981 consumption figures will be available shortly from the AIP. The approximate annual consumption for the four States is as follows:-

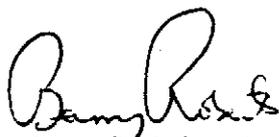
	<u>Approximate Annual Consumption (tonnes)</u>
New South Wales	150,000
Victoria	110,000
South Australia	40,000
Tasmania	10,000*

* A contact in Mobil separately advised that the Tasmanian consumption is approximately 16-17,000 tpa.

Bitumen is produced from Middle East crude oil vacuum residues. These crude oils are imported to make up the gap between Australia's consumption and indigenous crude oil production as well as for lube oil production. Current imports of Middle East crude contain in excess of 800,000 tpa of potential bitumen. Only sufficient bitumen is extracted from the vacuum residues to satisfy the market consumption, the remainder being left as a fuel oil blendstock.

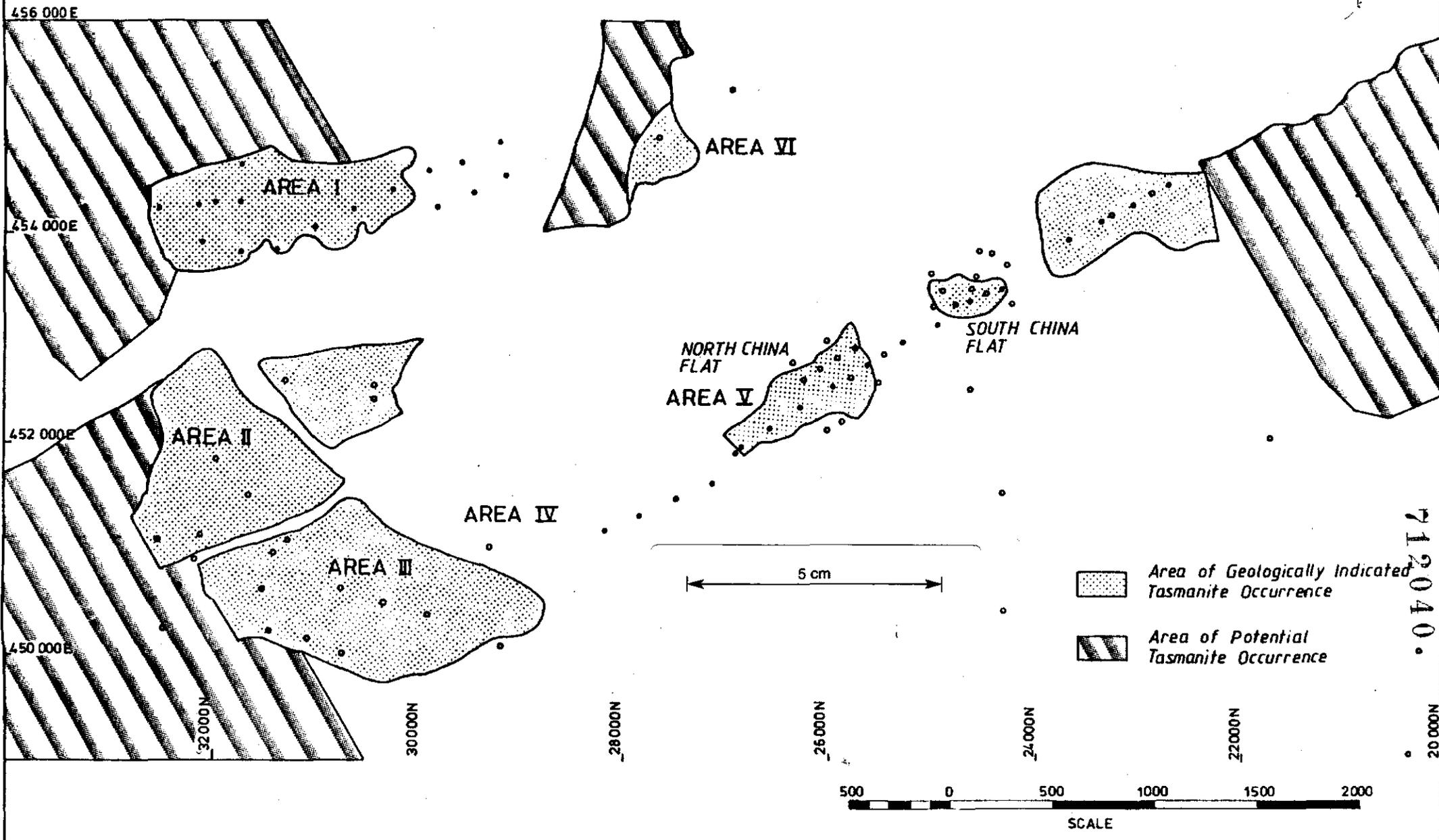
Bitumen is highly viscous and has a very high sulphur content. Therefore, it must be "cut-back" with a light oil (typically diesel fuel) before it is suitable for sale as high sulphur fuel oil. Typically 50-60% diesel fuel must be blended with bitumen before sale as fuel oil. The blending of diesel fuel into fuel oil represents a large debit to the refiners, as fuel oil is worth approximately A\$200/tonne versus diesel fuel at A\$300/tonne. Consequently sales of bitumen represent a lucrative business for the refiners; a business that they would take strong measures to protect. These measures would most probably involve price cutting, which the refiners will be able to justify, based on the low alternative value of bitumen (approximately A\$70/tonne fob if 55% diesel fuel is required).

The quality requirement for bitumen has increased substantially over the last 10 years following disastrous results with some bitumens (stories abound of whole freeway sections being stripped and resurfaced due to poor bitumen quality control). Quality requirements have now reached the stage that it takes nearly three years to gain acceptance of a new bitumen from the State Government road making authorities. It is also worth noting that the smaller road makers and industrial customers usually rely on acceptance from these authorities, before they in turn will accept any new product.


Barry Roberts

TASMANITE OIL SHALE EXPLORATION LICENCE 4174

Indicated And Potential Tasmanite Occurrence



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APPENDIX 2
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