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FEASIBILITY STUDY

for

ENDEAVOUR OIL COMPANY NO LIABILITY232 Victoria Parade
East Melbourne,
Victoria

A PRELIMINARY ASSESSMENT -

TASMANITE OIL SHALES AS A BITUMEN RESOURCEFred L. Hunt396, St. Helena Road,
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24 December 1975

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Summary drawing, scale 1" = 5 chains

Drill hole details, Goliath and Tasmanite
Mine Areas

1. SUMMARY

All major occurrences of Tasmanite oil shale occur in the Latrobe region, near the north coast of Tasmania, where there are some thirteen or more separate occurrences in a region 27 miles by 7 miles. Mineral rights to these shales are held exclusively by Endeavour Oil Co. N.L. under Exploration Licence 4/74, renewable at 1 May 1976.

The thin, flat-dipping shales of Permian Age outcrop along the banks of the Mersey River. For various reasons, exploration by underground methods has been preferred in past working and appears to offer cost advantages today.

The two basic approaches for extracting oil from oilshale are surface retorting and in-situ retorting, neither of which are wholly applicable here. Tasmanite shale has an advantage in that the oil spores are physically separable from the sandy shale by flotation, as shown by Manson and Walker in 1937. The oil produced from Tasmanite shale is unusual for its high bitumen content - the only known Australian bitumen source - and the nature of the 1937 process is such that an end product asphalt may be varied by metallurgical control.

No product specification is written for this unique asphalt. It is clear that whenever written, that specification will control plant design. Only then will plant and operating costs be carried out beyond guesstimates.

This evaluation attempts to assess whether or not an oil yield generalised for the whole seam at 24 imperial gallons/ton in the ground may be extracted, converted to bituminous asphalt, and show a profit.

My conclusion is that oil shales are at present uneconomic, but not without merit. Recommendations are made for continuing tests towards development of an asphalt suitable for hotmix usage, in anticipation of continued steep increases in the Australian refinery charges for bitumen.

2. INTRODUCTION

The Australian bitumen price has increased from about \$50/tonne to in excess of \$100/tonne in the period January 1974 to December 1975. These price rises show the effect of the price-fixing arrangements of OPEC, the Organisation of Petroleum Exporting Countries, and of increasing international shipping charges, passed on to the Australian bitumen price by Australian refinery operators who refine Kuwait and other crude oils. Australia has no indigenous asphaltic-base crude oil. First oil flows recently from the North West Shelf are reported to have similar characteristics to Bass Strait oils, and are a lighter type of oil.

Tasmanite oil shale is potentially profitable for its bitumen content, as the crude oil produced from this shale is bitumenous. The shale is also unique among world oil shales in that its kerogen arises principally from its content of fossil oil spores.

In the production of crude oil from shale in surface retorts, heat is applied to drive off the fuel vapours, which are trapped and condensed.

In the production of asphalt (1937 style) grinding of this shale, followed by standard froth flotation, allows preparation of a concentrate consisting of two thirds spore cases and one third ash. This concentrate can be converted to liquid bitumenous asphalt by thermal digestion in closed vessels - that is, placed in a horizontal retort and continually stirred under conditions of heat control until the temperature is raised sufficiently high (420°C) to dissolve all the oil spores into an asphalt of bitumen and fine ash, which is drawn off from the retort/digester.

Although bitumen has wide application its main use is in roadmaking. All are conscious of the road distances within Australia and the spreading nature of urban areas. Road construction for these purposes demands differing forms of binder and approaches to flexible pavement design.

In its search for economy in construction, the Victorian Country Roads Board is prepared to examine alternative binders. Non-technological factors can produce marked changes in flexible pavement design,

eg: (i) Tars, a coal gas plant by-product, were sought after as a road primer, and were extensively used up to the late

1950's. Thereafter, coal gas usage declined with increasing use of domestic electricity, and now most coal gas plants are inoperative. Over the same period, refinery bitumen primers obtained a greater share of an increased market.

- (ii) The dramatic rise in the price of crude oil since 1973 has prompted examination of various alternatives to bitumen, such as tars from brown coal and development of PVC combinations.

The CRB has tested one sample of asphalt as produced by Manson and Walker in 1939 - the sample contained 42.5% ash. The CRB Asphalt Engineers continue to be interested in the development of a binder from Tasmanite oil shale, even though results of testing were not immediately favourable. (Test operations on the supplied sample were difficult due to the amount of included volatiles and the high ash content.)

Any utilisation of tasmanite asphalt or tasmanite bitumen 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 asphalt or bitumen on private streets would be subject to local government control and so be under the same specifications. NAASRA technologists are examining alternatives to bitumen and the potential of tasmanite asphalt has been introduced to NAASRA technologists during the period of this assessment.

3. HISTORY

Nearly all the Australian States have deposits of shale oil, but only those in New South Wales and Tasmania have been worked to any extent. Records show that the first locally made kerosene was produced near Mt. Kembla in 1866, a deposit worked out by 1880. Shale oil deposits were then opened up at Hartley, about 85 miles from Sydney, for kerosene imports at that time were about 1 million gallons per annum (refined from American crude oil). Untreated oil shale was also supplied to gas companies to enrich the coal gas used for lighting.

Over 1 million tons of shale were mined in NSW in 1901, but this rate did not continue.

Work began on a new plant in Glen Davis, NSW, in 1938, although the deposits were not large. Between 1940 and when operations closed in 1952, some 1.3 million tons of Glen Davis Shale were mined for a yield of 52 million gallons of crude oil, refined to produce just over 26 million gallons of petrol. The residuals from retorting these shales are waxes. The Glen Davis shales are understood to be only 2 ft. in thickness, the 2 ft. seam averaging 100 gals oil/ton.

Tasmanite oil shale is unlike the NSW oil shales. It differs in composition in that the oil yield is dependent on the relative abundance of spore cases of the fossil *Tasmanites punctatus*. Crude oil produced from this unique shale is bitumenous, and is marked by its rank smell - a nauseating odour principally due to basic nitrogen compounds, more than the sulphur content of the shale.

In 1932, the Tasmanian Shale Oil Investigation Committee documented its findings after study of the industry between January 1931 and November 1932. This comprehensive study - published as Tasmanian Mines Department Geological Survey, Mineral Resources No.8, Vol.II, - is an excellent source of detailed information.

Up to 1935, oil was extracted from shale by surface retorting. The first small retorts were erected in 1910. In 1915, it was reported that 24,000 gallons of crude oil were produced from 600 tons of shale, a high yield probably due to selective mining practice. Intermittent testing continued over the following ten years, and various types of retort were erected. In 1927, some 60,000 gallons of crude oil were produced. Annual production increased considerably from 1931, with the erection of the nominal 12 tons/day Crozier Retort, but lack of profitability caused all significant retorting operations on the field to cease by 1934.

The Crozier, the largest 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. Remnant brickwork remains at Latrobe today. The experience of the Tasmanite Shale Oil Co. in retorting with this Crozier retort is given in the above publication in considerable detail in Appendix 5. The details given provide an appreciation of the variation in the yield of the shale, as mined for the purposes of five test runs. The results of these test runs are summarised in Table 1.

The total amount of crude oil obtained between 1910 and 1934 by surface retorting approximates 250,000 gallons. This 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. Evidence of bitumen used to grout a rounded pebble pavement around the retorts remains today - see photos 2 and 3.

In 1936, laboratory scale work at Launceston (Manson and Walker) demonstrated that an organic flotation concentrate could be prepared from tasmanite oil shale then converted into asphalt. Conversion was by heat transfer, in a tank with a horizontal stirrer, at temperatures up to 420°C. A larger digester convertor was constructed by the Tasmanian Mines Department at Latrobe, and this operated late in 1939.



Photo 1

Remains of old Latrobe convertor today.
Dimensions of steel cylinder 16'0"x3'6"



Photo 2



Photo 3

Retorting area, Latrobe. Photos show refined bitumen used to grout or penetrate river gravels.

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TABLE 1

Summary of Test Runs, CROZIER RETORT

(from Walker, 1932)

Run	Dates	Tons Shale retorted	Average Tons retorted/day	Production gal crude oil	YIELDS	Average mine assay	Average Recovery	SHALE SOURCE
1	23 Nov 1931 - 24 Jan 1932	1562	25 (max 34)	32,059	20.5 but retort throughput excessive & inefficient.	Not available		Top and bottom shales. Low grade part of workings
2	25 Feb 1932 - 24 Mar 1932	334	10.9	10,883	1783 cft/ton gas 32.4 g/t oil	42.8	75.6%	Attempt to retort only high yield oil shale.
3	12 May 1932 - 1 Jun 1932	327.5	11.8	9,993	29.6	Not available		Old workings, <u>two locations</u> Mixture of whole seam and selective mining.
3A	2 Jun 1932 - 17 Jun 1932	189.4	12.7	4,201	1144 cft/ton gas 22.2 g/t oil	25.8	86%	Whole seam as mined. from lowest grade in workings
3B	18 Jun 1932 - 29 Jun 1932	139.2	10.2	4,091	29.4 g/t oil	33.2	88.6%	Oil shales only - middle band excluded. Lowest grade workings

Test totals 2552.1 tons
Total erection of retort to end of tests 4375.1 tons

61,177 gallons crude oil
105,442 gallons crude oil

Note: Yields from shale source
runs 3 and 3B

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The research work at Launceston to the end of 1937 resulted in the production of 7265 lbs of concentrate which was converted to 5390 lbs of asphalt. In addition approx. 10 tons of concentrate were produced for future experimental purposes. Records of this and later work are lodged in the vault, Tasmanian Mines Department Launceston.

The plant installed at Latrobe has the following dimensions for a working capacity of about 1-2 tons of dry concentrate:

Length of shell	16 feet
Diameter	3'6"
Paddle shaft	10" dia drawn tube
Paddle arms extend from the shaft to the shell, and the paddle shaft rotates at 3 rpm	
Shell	½" steel plate

The convertor was required to act as drier/convertor which produced operating difficulties and resulted in excessive power consumption. Manson, Jan 1940, summarises the results of the three test runs (all from a cold or practically cold setting). Results are shown separately as Table 2, this report.

Total asphalt production was as follows:

Launceston, 45 lab scale tests, total	5390 lbs	asphalt
Latrobe, 3 test runs (Table 2)	5759 "	"
	<hr/>	
TOTAL	11,149	" "
	<hr/>	

This is approximately 750 gallons of asphalt, about half of which remains at Latrobe today.

Note: The filler content of this asphalt produces an increase in the weight per gallon by comparison with conventional bitumen.

ie: Tasmanite asphalt	146-150 gals/long ton
straight refinery bitumen	219 gals/long ton

Two short lengths of road were bitumenised with this asphalt, and apparently performance was acceptable to the road authorities at that time. Both test strips are non-existent due to reconstruction - one reconstructed as late as 1973 (Latrobe Council).

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TABLE 2
Summary of 3 Test Runs, LATROBE CONVERTOR (after Manson, 1940)

Run	Date	Dry Charge Tons CONCENTRATE POWDER	Conversion Time (hours)	Products / Percent of Concentrate			Logbook records Launceston			
				ASPHALT	OIL	GAS	Bitumen lbs	Oil lbs	Gas lbs	
1	7,8 Nov 1939	1.2	22.5	71.2	9.2	5.1	1917	138		
2	9,10 Nov 1939	1.2	25.5	73.2	12.7	5.9	1970	159		
3	30 Nov, 1 Dec 1939	1.2	27	69.6	14.2	6.8	1872	185		
							TOTAL	5759 lbs Bitumen		

ASPHALT PRODUCT :-

Percentage of Asphalt

Comparisons between ..
Bitumen soluble in carbon bisulphide
Ash content of filler
Volatile matter in filler

	Latrobe test run 1	Launceston pilot plant
Bitumen soluble in carbon bisulphide	58.95	50
Ash content of filler	35.35	46
Volatile matter in filler	5.7	4

NOTE: Volatile matter in filler includes bitumen adsorbed in filler, carbon formed in conversion, untreated or partially converted concentrate, carbonate carbon dioxide and water.

The technique established in 1939 was not carried beyond this early processing to any sub-commercial practice, due to lack of Federal Government support. The Tasmanian Government supported an additional drilling campaign in 1940/41 which successfully demonstrated continued reserves. The Tasmanian Government has been unsuccessful in attempts to obtain Federal support at various times up to (at least) 1949.

To recapitulate -

the process envisaged requires crushing and grinding of the shale to a size suitable for the extraction of oil spores, followed by conversion of the oil spore concentrate into asphalt (or bitumen).

Manson and Walker developed a process. Its significance today is related to -

- . road authority acceptance of either asphalt or bitumen
- . mining economics and the yield of oil
- . improvements in concentrate preparation
- . development of a concentrate convertor/digester capable of throughput of the order 50,000 tons concentrate per year

4. PROCEDURE IN ASSESSMENT

This study has included examination of various Tasmanian Mines Department memos and correspondence between 1930 and 1955, published literature, unpublished Government maps and Tasmanian Mines Department records, together with private company data supplied by Endeavour Oil Co. N.L., or by Mr. L.G. Nixon of Nixon and Associates on behalf of Endeavour Oil.

The history of previous attempts to establish the Tasmanian oil shale industry has been described above.

This report now discusses -

(5) The Resource

The area geology is recounted by Nixon, June 1975, EL 4/74, Report on Drilling. This evaluation is only concerned with geology at a mine scale and its influence on economics. A limited description of the shales is given, and the resource is examined in detail to assess yield, and consider reserves of an "indicated category" (Aus.I.M.M. definition).

(6) The Markets

A preliminary survey is made of the Victorian bitumen market, its suppliers, its problems in transportation and the extent of competition. Market influences which appreciably affect sales costs are identified. Increases in bitumen prices are recorded. The current product testing position is stated.

(7) Mining Parameters

Operations as open cut are compared with underground in the light of excavation characteristics established through seismic work by Golder Associates. Selective mining is discussed.

(8) Overall Economics

An attempt is made to assess likely costs and arrive at a level of bitumen process which may be economic.

Recommendations for further work follow.

5. THE RESOURCE

Nixon, 2 December 1974, gives a clear description of the oil shale and its geological environment.

The mineral portion of the shale consists of a fine grained siliceous mudstone. As Tasmanite oil shale, this siliceous mudstone contains brownish bodies of flattened circular shape - Tasmanites punctates, microfossils of marine origin. These Tasmanite spores produce nearly the whole of the oil yield. Over most of the producing areas, the Tasmanite spores occur in relative abundance in two beds separated by a shale horizon relatively poor in Tasmanite - see Figures 1 and 2. However, in some areas Tasmanites may occur in relative abundance in three horizons - see Figure 2 - where elsewhere only one horizon is recorded.

Early operators give these seams an average thickness of 5'2" on the workable part of the field. Selective mining was practiced, and as a result early operators assessed the effective thickness as 4 feet when developing tonnages for reserves.

These thin, shallow dipping, Permian Age shales are not folded, but faulting is common. The shale tends to occur as a number of more or less separate blocks at different altitudes being separated from

neighbouring blocks by faults -

eg: 250 ft downthrow Goliath Mine to Tasmanite Mine

- or by diabase intrusions, or both.

The seam of shale, with its richer and poorer sections, is illustrated by Figure 2, showing drill hole data and oil yields for diamond drill cores T1, T2 to T7.

Geological reserves of this shale are extensive. Substantial ore reserves have been inferred by a number of geologists, and recently listed by Nixon (June 1975). The writer accepts that inferred reserves are substantial.

eg: Shale horizons to the north of the old Goliath Mine (see drawing) were drilled in 1933. No determinations of yield are on record. However, the drill logs show whole seam shale thicknesses in the range 4'8" to 5'4" north and north east of the Goliath Mine workings, so that approx. 1 million tons of shale may be inferred in that location. The reserves are not amenable to open cut mining.

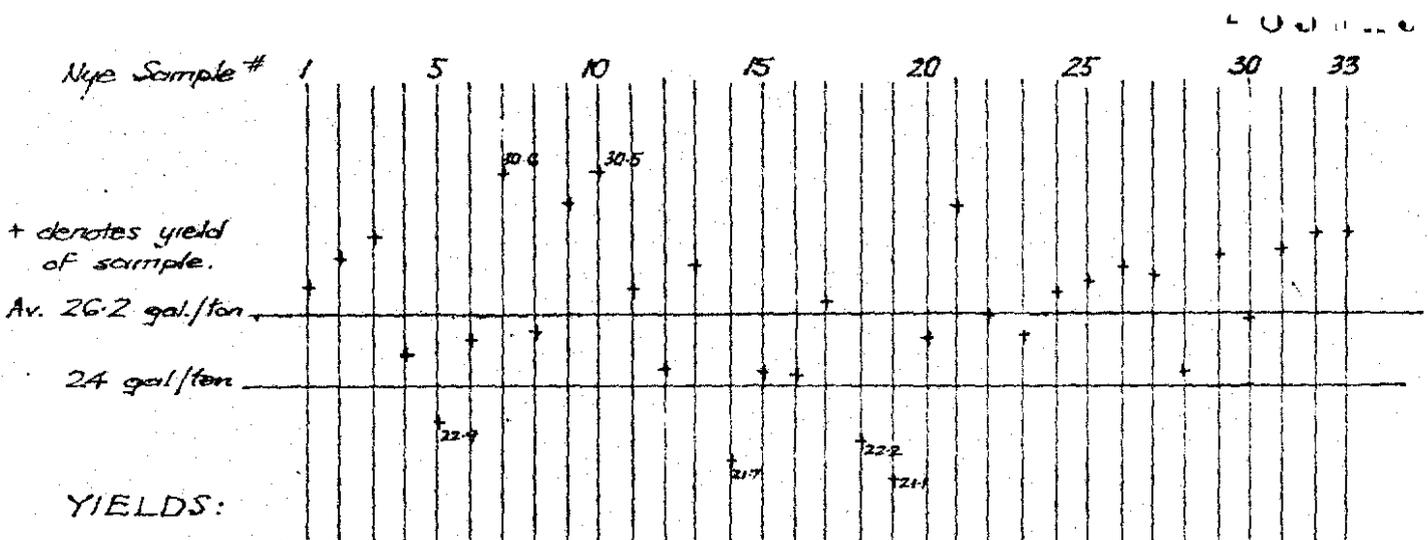
Although shales are inferred at a considerable number of locations, some areas of drilling will probably be shown to contain only thin layers of oil shale - geological horizons, probably never economic. Nevertheless, the overall possible tonnage is likely to be of the order 20 million tons.

Indicated Reserves

At present, the best defined reserves are those north of the old Tasmanite mine (see drawing) following drilling in 1941. The drilling records available (1933 and 1941) plus mine sampling (1932) indicate that the area between the old Tasmanite mine and the diabase intrusive to the north contains some 1 million tons of shale as one mining horizon (top, bottom and middle bands) at a generalised grade : 24 gals crude oil/ton shale in the ground and probably 21 gals/ton recovered. These indicated reserves are not amenable to open cut mining.

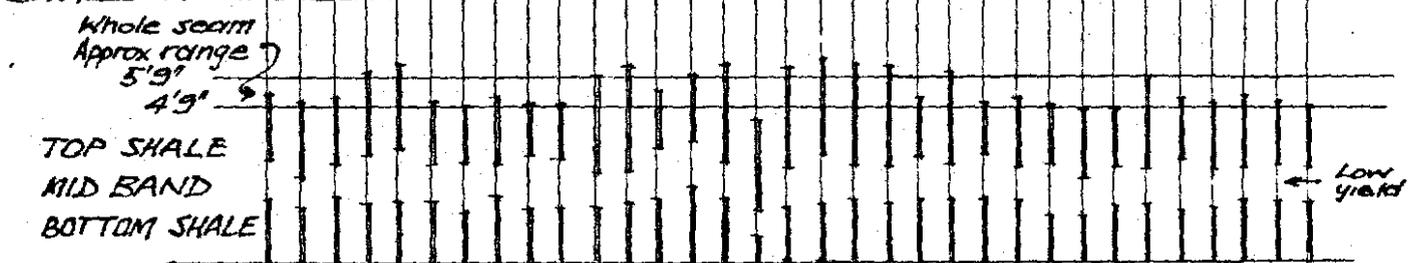
Note: This area alone holds crude oil which could provide the equivalent of several years demand for bitumen in and around Melbourne.

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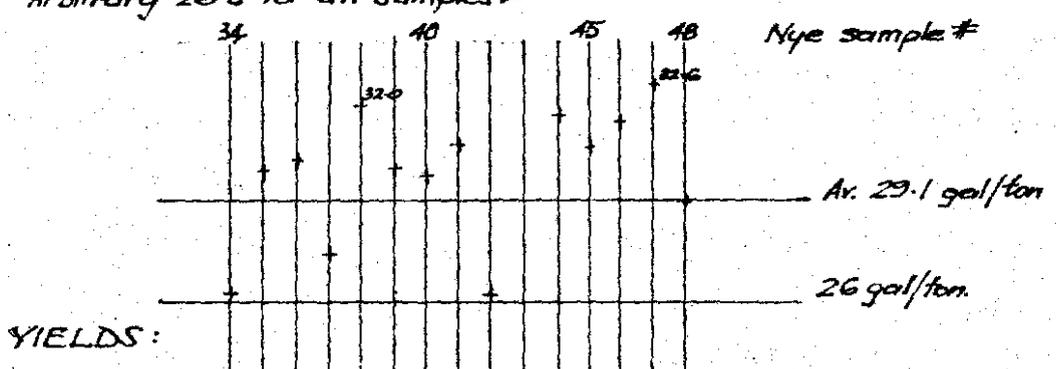


GOLIATH MINE SAMPLING - Nye, 1931

Comparative SHALE THICKNESS.



Arbitrary zero for all samples



TASMANITE MINE SAMPLING - Nye, 1931

Comparative SHALE THICKNESS

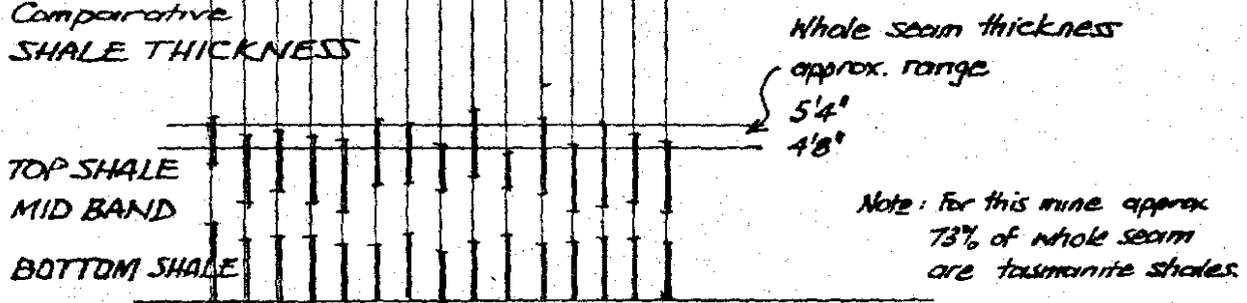
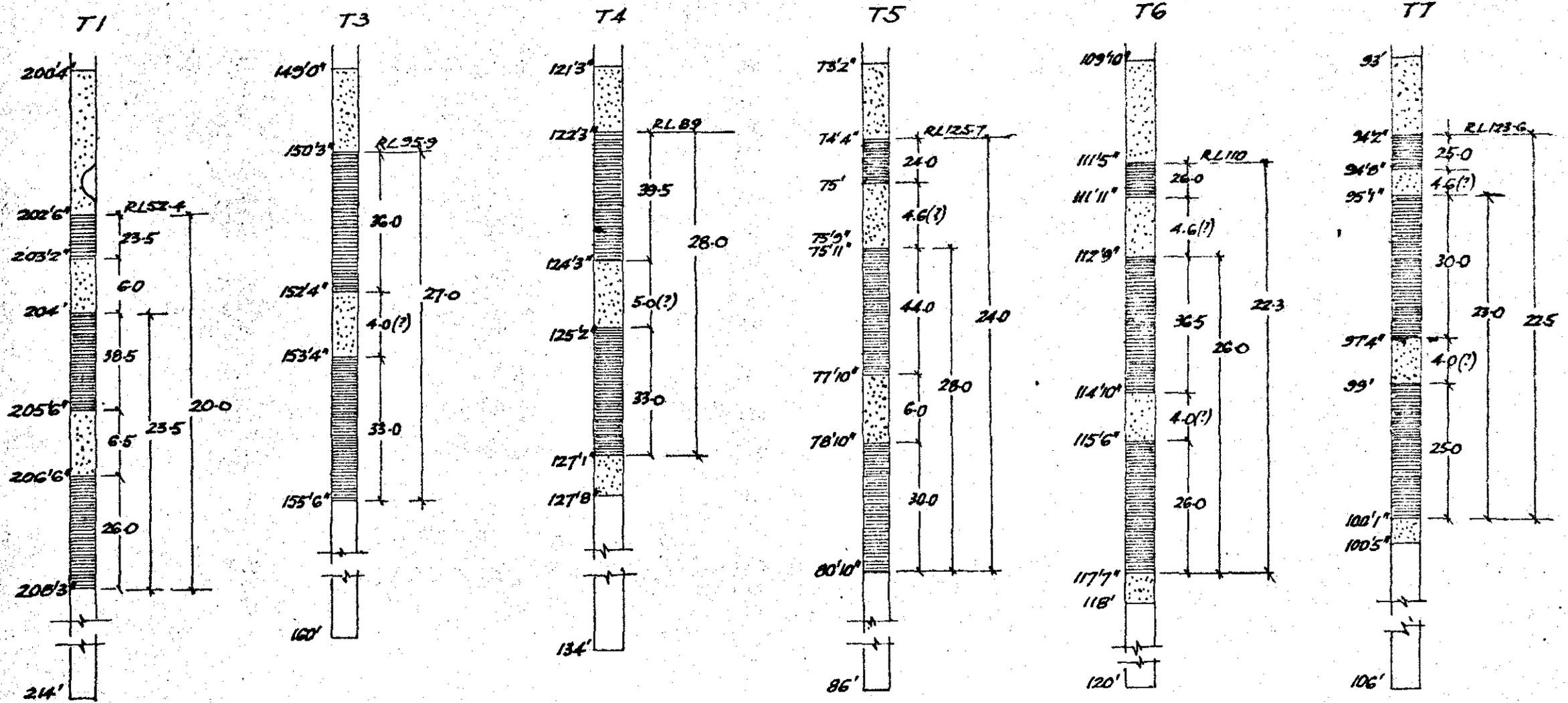


FIG. 1. - Illustration: Results of sampling, Nye, 1931

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From Drawing by Q.I. Henderson
- 30. July 1941.



Indicated Oil Yield, deduced from Ash Content of Diamond Drill Cores.
Yields (at right) in gallons per ton.

Vertical scale 1" = 2'0"

Fig. 2. Drill Hole data and Oil Yields, holes T1, T3-T7 (1940-41 Drilling Campaign)

5 cm

Fred L. Hunt
Dec. 1975.

Tonnage Assessment Comments

Tasmanite shale is a variable raw material. A series of constant volumes will show differing weights. Inspection of Fig.1, illustrating results of sampling by Nye, 1931, show the variation in thicknesses and yields which accordingly alter the weight of a constant volume.

ie. there are difficulties in establishing gross tonnage figures on the basis of some arbitrary figure of weight/cubic yard.

However, an arbitrary figure is commonly used. To illustrate this difficulty, relationships shown by Kurth, 1932, are presented in Table 3.

Ash %	Specific Gravity	Oil gal/ton
61.9	1.71	65.0
66.5	1.87	52.6
68.3	1.90	45.4
70.0	1.94	44.0
71.6	1.94	46.2
75.3	2.04	35.9
77.5	2.12	30.0
79.9	2.14	23.6
80.2	2.17	27.4
81.7	2.25	22.8
84.4	2.24	16.2
84.5	2.29	16.5
89.3	2.48	9.6
89.8	2.56	7.5
91.1	2.48	6.4
93.5	2.65	2.7

TABLE 3

Relationship between Oil yield and Ash
Kurth, E.E., 1932 (MinRes.No.8 Vol.11)

Notes:

- 1) Oil yields may be estimated from ash content, but these are to be regarded as maximums.
- 2) The SG of the dry shale bears close relationship to the oil yield, and the oil yield may be inferred to within 2 or 3 gal/ton from simple determination of SG.

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Crozier retorting on test run 3A processed shale from the whole seam. The daily retort figures reflect the constantly varying raw material, and are listed here as Table 4.

Daily retorted Tons	Recovery gals oil/ton
8.3	30.3
12.3	24.0
13.1	25.0
13.1	21.4
13.1	21.4
12.9	24.2
13.4	20.8
4.4	17.4
8.9	17.4
13.6	22.8
13.6	18.4
11.2	30.4
12.6	22.4
13.0	22.7
10.4	23.4
4.1	20.2
7.3	20.2
12.4	19.2
	(av. 22.2)

TABLE 4
Crozier Retorting, whole seam shale. Test
Run 3A, June 1932

Note: The average, 22.2 gal/ton, represents 86% recovery on the mine assays.

Metallurgical work in 1940 used -
 specific gravity whole seam 2.0
 specific gravity organic matter 1.1

In this assessment, the writer has used an SG of 2.25 to establish tonnage at whole seam grades.

Indicated reserves are given nominal thickness of 5'9"

For SG 2.25 x 62.35 - approx. 140 lbs/cft

$$\therefore \frac{140}{2240} \times 43560 = 2710 \quad \text{say, 2700 tons/acre foot}$$

60 acres by 5.75 feet @ 2700 = 940,000 tons, and a figure of 1 million tons is adopted.

The Oil Yield

Various estimates of general yields are as follows:

1) Manson and Walker, September 1936

21,000 tons whole seam shale will produce 3873 tons asphalt.

Yields expected from these figures -

Shale oil : approx. 25 gals/ton shale

Production - ASPHALT (35% ash filler) 1 ton per 5.4 tons shale
plus FUEL OIL by-product 8 gals/ton shale

2) Director of Mines, evidence to Hobart hearings, June 1944

4290 tons whole seam shale will produce 766 tons asphalt.

Yields expected from these figures -

Shale oil : approx. 24½ gals/ton shale

Production - ASPHALT (35% ash filler) 1 ton per 5.6 tons shale
plus FUEL OIL by-product 7½ gals/ton shale

Elsewhere in this evidence -

Shale oil 26 gals/ton shale inferred from drilling to
north of Tasmanite Mine.

3) Nye, October 1931

Mine sampling in the Goliath and Tasmanite Mines for purposes of the Shale Oil Investigation Committee, checked the various horizons at 48 sampling locations.

Yields, on average, were -

Tasmanite Mine 29.1 gal/ton shale whole seam

Goliath Mine 26.2 " " " " "

For the Tasmanite Mine, Nye observes a range of thickness 4.4 to 5.7 feet, and a range of yields 18.2 to 32.6 gals/ton.

The observed range of thickness for the Goliath Mine is 4.2 to 6.1 feet, and a range of yields 21.1 to 30.6 gal/ton. The results of the sampling programme are illustrated as Figure 1.

4) Tasmanite Mine drilling

1941 Drill logs and particularly drawings made available

(correspondence 20 Nov 1975) give details of holes drilled and show analyses for holes T1, T3 to T7 in a series of 14 holes. These analyses form the basis for the statement - "Shale reserve (exclusive of thin band of roof shale but including middle band) is 516,000 tons with average oil content 26.0 gal/ton."

The writer considers the addition of the thin band is likely (as mining dilution) and would lower the yield figure to about 23.8 gal/ton.

However, note that no analyses are available for holes T8 - T11 and T13 - T16, even though the logs record oil shale intersections commonly of the order of 6 feet, ie. comparable with the 1931 sampling widths.

In correspondence 20 Nov 1975, the Director of Mines advises that -

"There is no report to accompany the 1940-41 drilling and no evidence of oil content except where occasionally shown...."

This series of holes is set out on a 5 chain grid immediately due north of the Tasmanite Mine. The horizon is faulted, but not frequently, and occurs at depths of from 55 feet just north of the old workings to 180 feet below surface, 200 chains further north. The surface is approximately level in the N-S direction and slopes about 1 in 20 in the E-W direction.

1933 Holes drilled to the north of the above (1941) drilling confirm continuance of the existence of shale up to the dolerite intrusive position, and beyond it. Note, however, the records of 1933 drilling suggest a lower yield (order 20 gal/ton) - holes #2, #3, and #4 are lower yields. Drilling recoveries may have affected these results.

No yields are available for holes drilled north of the diabase intrusive.

5) Crozier testing

This is discussed earlier, and summarised in Table 1. An important aspect of this work is that it gives clear record that yields on a mine scale may vary considerably from any arbitrary average. It also records the likely recovery of oil as a percentage of mine assay.

The above discussion and the earlier review of Crozier results suggest an extracted yield of 21-22 gal crude oil/ton of whole seam mining may be a realistic yield. Accepting Manson and Walker experience for asphalt yield, we can anticipate 1 ton of asphalt per 6.3 tons shale.

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Sulphur Content

The sulphur content of Tasmanite crude oil lies in the range 2.1 to 2.5%, while the sulphur content of the shale is commonly between 2 and 3%.

Sulphur is present in two main forms -

- a) as part of the composition of the spores (about 1% by weight of the shale)
- b) as pyrite in the mineral matter of the shale.

Minor amounts occur as sulphate sulphur.

The average sulphur contents of various sections are tabulated below:

	Goliath Mine	Tasmanite Mine	Latrobe Field
Top shale %	2.54	2.78	
Middle band	2.52	2.54	
Bottom shale	2.77	3.01	
Whole seam	2.61	2.77	2.65-2.69

Sulphur content of this order in asphalt or bitumen is not a disadvantage. However, refined products from crude oil in retorting (1930's) produce on use an exhaust fume "markedly sulphurous and malodorous". In any future development, Tasmania's Environment Protection Authority would be concerned to ensure air quality standards for sulphur dioxide emission are met.

6. THE MARKETS

The Tasmanian consumers of bitumen represent the closest market, but as Victorian markets are larger and more flexible, this preliminary study considers Victoria, its suppliers problems in transport and extent of competition. The objective of the market study was to develop an appreciation of normal sales procedures and the types of products sold, and identify aspects of sales which may have significance in cost considerations.

Introduction to the Victorian bitumen markets : the Suppliers

Victoria's first petroleum "refinery" was the C.O.R. distillation plant set up at Laverton, 14 miles from Melbourne, to treat crude oil imported from Iran. The year was 1920: in that same year shale from Latrobe was retorted, and the crude oil shipped to a small

refinery at Yarraville, Melbourne, where high grade motor spirit was produced.

The first large capacity refinery was jointly erected by ESSO/MOBIL in 1949, at Paisley, near Altona. Mobil was the marketer for the various products, including bitumen.

SHELL entered the bitumen market in 1959, although their Geelong-Corio refinery was on-stream earlier (1954). This represented the first competition for Mobil, although Shell are considered to be less aggressive than Mobil in marketing bitumen. Shell refines Basrah and Kuwait crudes. As mentioned in the Introduction to this report, the 1950's was the period where coalgas tars were replaced by bitumen primers. From 1962, Esso marketed bitumen, taking their share of products from the Esso/Mobil Paisley refinery. Esso markets from a bulk depot at Albury-Wodonga - their aim is bitumen sales to the CRB Benalla Division, plus supply into central and western New South Wales. In 1966, the BP Westernport refinery commenced production of most petroleum products, including bitumen (the exception being some fuel oils).

The topography, geography and transport links in Victoria, coupled with the locations of these refineries, tends to produce "natural" divisions in the bitumen market.

ie: SHELL at Geelong services the Western District and into South Australia

BP at Westernport supplies eastern Victoria and into the South Coast, NSW, and the ACT.

MOBIL from Melbourne-Altona controls the central Victorian and metropolitan market, and into NSW through Echuca

ESSO operates from Wodonga, where the subsidiary Allen Bros. operates bitumen road transport and provides bitumen laying facilities.

A considerable volume of bitumen is consumed in the Melbourne metropolitan area where pavement designs commonly call for hotmix, hotlaid asphalt as well as prime and seal bitumen. Bitumen for this asphalt is supplied to the depots of quarry operators who manufacture plant mixed "hotmix" and who distribute and lay hotmix on contract. Some of these hotmix operators are -

- . . Albion Reid, wholly owned subsidiary of BORAL
- . Readymix Asphalt
- . Pioneer Asphalt (also interested in mineral exploration)

Contractors who are bitumen sprayers are

- . Emoleum (Aust) Ltd.

It is to be noted that there are few major operators in this field/
 Demand for bitumen and/or asphalt in the metropolitan area of Melbourne
 is seen in the Government Statistical Returns for Melbourne area
 (including Bulla, Berri, Cranbourne, Hastings, Mornington and
 Whittlesea), viz:

30 June 1973 :	10,934 miles of road	7,551 miles paved/sealed
30 June 1974 :	11,150 miles of road	7,750 miles paved/sealed

thus, new bitumen surface, approx. 200 miles 1973/74

The Products and Prices

Table 5 and Table 6 set out the current CRB usage of tar primers,
 cutback bitumen primers, primer sealers, sealers and asphaltic
 concretes. The figure below shows the dramatic increase in prices
 for bitumen at the refinery gate Melbourne.

No attempt is made to forecast future price.

Freight costs are additional.

Purchase is on the basis of weight.

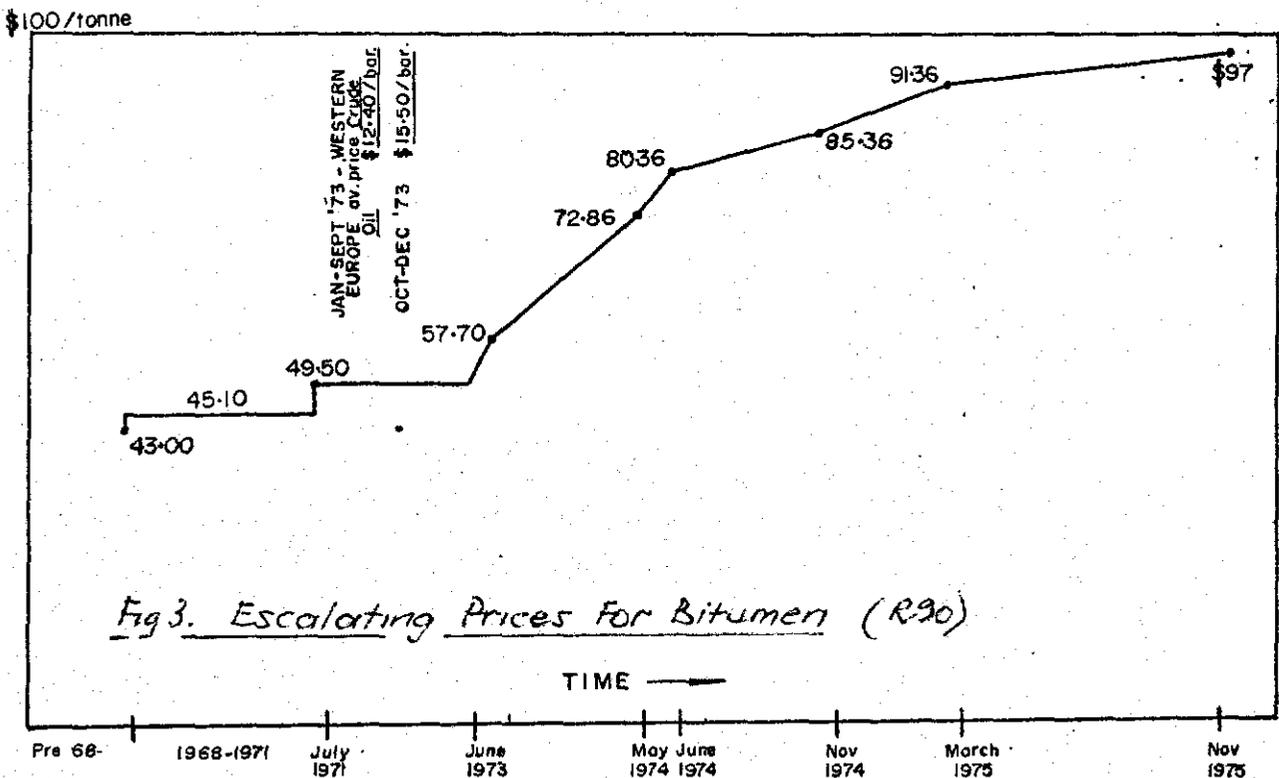


Fig 3. Escalating Prices For Bitumen (R90)

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TABLE 5
Road Primers in Use by C.R.B., VICTORIA

TYPE	SOURCE	SUPPLIER TO CRB	USE	AMOUNT/PRICE
(1) Vertical Retort Primer TAR	Produced from black coal as a by-product in continuous retorting to manufacture town gas	a) Municipal gasworks City of Wagga Wagga NSW b) Albion Reid, resellers of tar from Geelong and other gasworks	A light primer, mostly used in south of State. Suitable for tightly bonded pavements. Can be fluxed with tar oil.	
(2) Intermittent Retort TAR (slightly heavier than VR Tar)	Produced from black coal as byproduct during town gas manufacture in horiz.retorts	Albion Reid, reselling to the South Australian Gasworks, Osborne, S.A.	Useful on a wide variety of pavements, especially some limestone pavements	"less than koppers"
(3) Coke Oven Tar Primers	By-product of the carbonisation of black coal during manufacture of coke for use in steel furnaces	Koppers Aust.P.L. Newcastle, NSW	3 grades; used as very light primer, light primer and medium primer	\$80/tonne including \$20/tonne freight. Nov 1975 400-500 tonnes pa
(4) Cutback bitumen primer	a) Refinery produced b) Field produced by adding by adding asphaltic oil and kerosene to 85/100 bitumen	MOBIL - SP 30 etc. SHELL ESSO BP	General primer usage	\$72/tonne, Melbourne 1975
(5) Prime binders	Proprietary blends of tar or cutback bitumen or bitumen emulsion with adhesion agent incorporated	MOBIL "SP 1000" BP "Primesealer" SHELL "SSP 1500" ESSO "EP 1000"	Now used in heavily trafficked areas in lieu of prime and seal. Final seal applied 6-18 mos later	7000 tonnes 1974/75 \$80/tonne Melbourne Oct 1975

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TABLE 6
Sealers and Bitumenous Concrete in use by C.R.B. Victoria

Type	Source	Quantity		
		Year	Tons	
R90 Bitumen	Refinery Specification, AS-A10-1967	1965-1966	30,418	Cost in bulk at refinery - September 1975 - \$91.30 /tonne November 1975 97.00 /tonne + 26,000 tonnes (compare Jan 1974 - \$49.50/tonne)
		1971-1972	36,088	
		1972-1973	28,800	
		1973-1974	26,143	
		*1974-1975		
Bitumenous Concrete (Asphalt)		1973-1974		Total CRB usage -12,300 tons bitumen supplied for asphalt preparation Bendigo CRB division laid 13 mm asphalt, used 3576 tonnes, cost \$85200 @ approx 6% bitumen; asphalt cost \$21.60 - \$26.50 /tonne in Bendigo Total CRB estimated 25-30,000 tonnes
		1974-1975		
		*1974-1975		
Cold Asphalt		1974		Bendigo Division CRB used (for patrol work) 3,000 tonnes, cost \$58934 @ approx 5% bitumen, cost at local plant \$17.40/tonne

* Note fall in use of straight bitumen and increased demand for asphalt (hotmix) which probably is cost/benefit reaction to increased bitumen price

These prices apply to bitumen at 975 litres/tonne, or 214 imperial gallons /ton.

A primer such as SP 30 at 15°C provides 1090 litres/tonne. Primer binder SP 1000 at 15°C provides 1050 litres/tonne. By comparison, the asphalt from Tasmanite is heavy (due to its ash content) at approx. 150 gal/ton, and as application rates are based on volume (eg a reseal may be applied at a rate of 1 litre/sq.metre) the price considered for Tasmanite asphalt must be adjusted down to allow for decreased coverage /ton, and the lower pure bitumen content - to a figure of perhaps \$60 to \$70 /ton at present. To justify a present \$70 / ton price, the Tasmanite asphalt would need to offer particular advantage in use. At 6.3 tons shale/ton asphalt, a price of \$60-\$70/tonne of asphalt (of the 1937 type) represents only about \$10/ton shale in the ground - say mining and milling operating costs.

However, it is clearly possible to improve the price expected by changing the character of the asphalt. Further increases in bitumen prices are also a real possibility.

At current prices, the writer firmly believes there is merit in the pursuit of techniques and/or alternatives to the present approach for the extraction of bitumen.

Customs in distribution

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 influences on costs are:-

1) the seasonal emphasis

Hot laid country road primes 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 provide 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.

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 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 rail 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.

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.

Hotmix Asphalt

Some advantages of supplying into this field are mentioned above. Metropolitan operations on a batch basis give near year round cash flow and sales to creditable purchasers. As mentioned, the scale of operation is large - gross demand is now about 900,000 tons p.a. I understand the Albion Reid share is about 30,000 tons p.a. so that the Government authorities and private operators Readymix and Pioneer supply the bulk of this demand.

Both Readymix and Pioneer are private enterprise quarry operators who are providing all the components of hotmix with the exception of bitumen. As such, either must be attracted to the possibilities of development of a mined or quarried bitumen source, under joint venture, were Endeavour to approach them. Readymix already operate in Tasmania. Pioneer are currently joint venturing into mineral exploration in western Victoria, with Pennzoil, and elsewhere.

The current position re testing of Tasmanite asphalt

As mentioned in the Introduction to this Report, engineers of the CRB Asphalt Division have tested a sample of asphalt obtained by Endeavour Oil from the drum held at Lanuceston Mines Department laboratories. This sample contains 42.5% ash - TMD Analysis No.742552, 3 October 1975. The Australian Road Research Board has samples of the same material but no test results are expected from the ARRB in the immediate future.

The high ash content has confused meaningful interpretation of results in testing. Also, the volatile content of the sample complicated test procedures. Any other tests to determine if the product is usable at normal working temperatures (180°C) should be conducted on samples with

- . less volatiles
- . higher flash point (automatically improving volatility)

The CRB approach is that no specification can be written about this asphalt at present. Further, the tests completed were of limited use in guiding any recommendation. However, it is a new material, and the CRB recognise that new test procedures may need to be evolved. The product has potentially good characteristics, and the CRB have indicated their willingness to pursue testing.

In discussions on the 19 December 1975, (J. Bethune and H. Tasker, CRB, with F.L. Hunt) it was agreed that it would be desirable to test small amounts (1 kg) of differing asphaltic products in an attempt to obtain comparative test results.

- ie: sample of 15% ash asphalt
- sample of 30% ash asphalt
- sample of retorted product bitumen

Some basis for guidance to product development may eventuate from comparative tests.

Further it is understood that the bitumenous product or products which are developed would be required to be tested over a period of months or year(s) before any specification(s) may be finalised.

Future road testing

To assist in the appreciation of the scale of plant needed to provide test asphalt/bitumen, the following notes are given:

Test strip size - say, 800 yards x 8 yards
= 6,400 sq.yards

- * Primer and 1 coat seal:
say, 0.32 gal/sq.yd needs 2,050 gals for test
- * Two coat seal:
say, 0.45 gal/sq.yd. needs 2,870 gals for test
- * Asphalt, dense graded 6% bitumen
150 lbs/cubic foot
 $\frac{1}{2}$ " compacted needs 2,050 gals for test

Thus, preparation of about 2500 gals per test, for say 8 to 10 tests, is anticipated.

As a matter of comparison, the outputs of the Crozier Retort and the Latrobe Digester are restated. Use of bitumen from the Crozier Retort is recorded on photos 1 and 2, this report.

a) CROZIER

12 tons/day throughput gives 264 gals crude oil/day

Refined as Petrol	6.35	
Kerosene	13.25	
Diesel Oil	48.70	
Tractor Oil	8.92	
Bitumen	12.63	89.85
		<hr/>
Losses in refining		10.15
		<hr/>
Crude oil refined		100.00 gallons

Clearly, the scale is inadequate, even for test work.

b) Digestor

Input	1.2 tons dry concentrate
Output	1900 lbs asphalt per 24 hours
	ie 127 gals/24 hours (578 litres)

There well may be some merit in reconstructing a digestor to assist in the preparation of quantities of asphalt for test strip work for the scale is probably adequate.

7. MINING PARAMETERS

A number of factors are discussed:

Weather

Rainfall annually for Melbourne is a yearly mean of 658 mm (nearly 26 inches). In contrast, the yearly mean for Devonport - nearest weather station to Latrobe - is 924 mm (over 36 inches). The monthly figures below show distribution through the year.

January	38 mm
February	59
March	43
April	84
May	105
June	89
July	112
August	110
September	76
October	85
November	57
December	66 mm

Topography

Photographs 6 and 7 illustrate the topography at the Goliath Mine, and to the north of that mine. That topography is reasonably typical around Latrobe, apart from river flat areas, seen in photo 4.

Transport

The area is well served by transport links, including those through the port of Devonport, which is also on the Mersey River at its outlet to the sea. Figure 3, the extract of the Tasmanian Lands Department map "Forth", scale 1:100,000, illustrates the situation.

(CULTURAL DETAILS, MAP EXCERPT)

INFORMATION IS MISSING FROM THIS REPORT.

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These photographs illustrate topography in the Tasmanite Mine area.



Photo 4

View from Tasmanite Mine workings to the south
Photo taken above the Mersey River, north bank,
at the Great Bend of the Mersey - see drawing.
APM pumphouse seen at left.

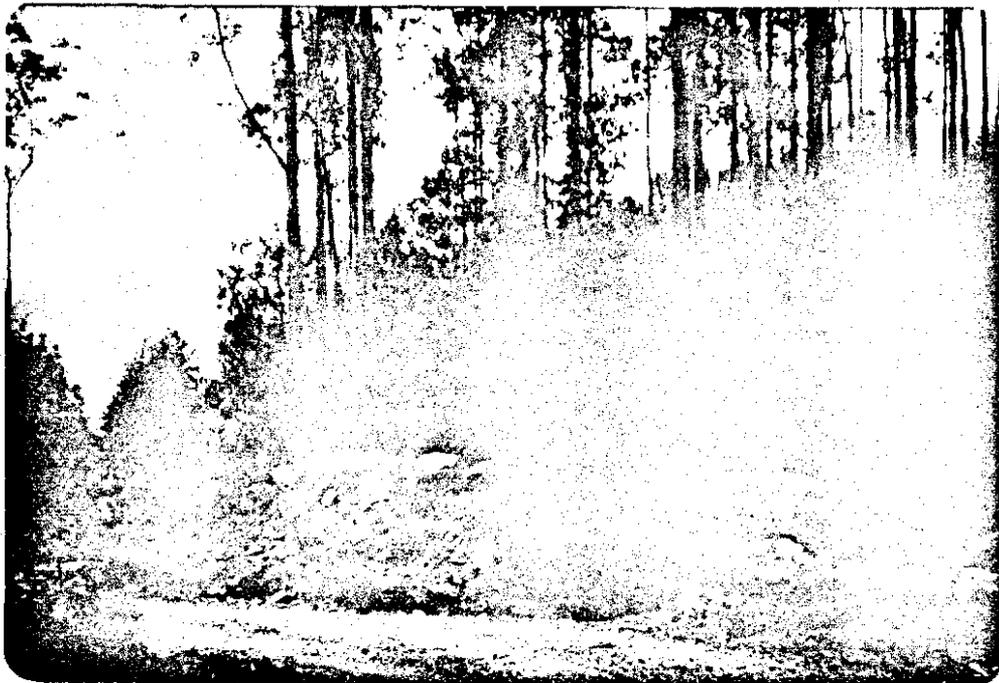


Photo 5

View to south, Tasmanite Mine. Boulders in
foreground, centre, lie on access track into
mine portal. Road is new access to APM
pump station.

The photographs below illustrate topography in the Goliath Mine area



Photo 6

Seismic survey in progress along the line of main adit, Goliath Mine, 29 Sept 1975. Traverse 1 of survey. Photo looks south



Photo 7

Goliath Mine airshaft, collapsed, in mid foreground Goliath workings (underground) to right. Valley of Mersey River immediately to left. Photo looks north.

Power and Water

No assessment has been made of demands for these resources. The Latrobe area lies within the Mersey-Forth Hydroelectric Power Development, but well downstream from the dams on the Mersey River. Locally, Australian Pulp Mills have a pumping installation on the Mersey River at the Great Bend, by the site of the old Tasmanite Mine - see Photo 4.

Note: Manson's work suggests that water consumption may be of the order 10.7 tons per ton of shale.

Description of Material to be Mined

Figures 1 and 2 earlier in this report give an appreciation of the seam to be mined.

The shale occurs as a seam dipping horizontally and at low angles, up to 1 in 10. Thickness of the order 5 feet is normal, and local faulting - $1\frac{1}{2}$ to $4\frac{1}{2}$ feet vertical displacement - is reported. The whole of the shales are block faulted, large scale, with vertical displacements of the order 250 feet at least - these faults are infrequent on mine scale. The Tasmanite shale is light grey to light brown in colour, having the general appearance of an ordinary shale.

The shale outcrops in a number of areas, but dip and topography combine to quickly produce depths to shale exceeding 50 feet.

The Tasmanite shale is described as

- . soft but tough
 - . easily split, but extremely difficult to break across the grain.
- Hand spalling was practiced.

It reportedly produces few fines in blasting (1930 practice).

Old workings are described as having a sound roof and fairly clean floor. The old method of selective mining removed the central low grade mudstone first then broke and removed the shale. Kurth (1938) mentions that "the middle band assists considerably in mining the shale as it is more easily removed (than Tasmanite shale) ... (but) it can always be readily distinguishable from average grade shale." As this visual difference is not marked, one wonders how effective the selective mining was under 1930 practice. This band of low grade shale is about 12 inches thick dividing the two high grade seams as illustrated in Figure 2, previously.

Numerous pebbles of quartz, quartzite and granite are distributed irregularly throughout the various shale bands. The larger workings are by the Mersey River. No wet conditions are described, but the level of working there was above river level.

Rate of extraction

Considerations of marketing suggest that the likely rate of extraction for this project is about 50,000 tons bitumen/asphalt per annum.

At a ratio of 6.3 tons shale (whole seam) per ton product, the seam mining rate is about 300,000 tons p.a., representing the removal of 25 acres per annum.

Consideration of open cut mining

The crux of this problem is cost. The amount of overburden per ton of end product is unusually high in this situation, for there is a multiplier effect on overburden due to the number of tons of shale to be mined per ton of product.

Work by Nixon and Associates sought to establish areas suited to open cut operations, and this work included a drilling programme to seek shale horizons at depths of less than 70 feet. Principal results of this drilling are listed in Table 7.

Under this current study, Golder and Associates, geotechnical engineers, were asked to report on the likely excavation characteristics of overburden as a basis for the assessment of probable open cut mine costs. Seismic reflection traverses were used in traverses over the Goliath Mine and to the north of the Goliath Mine, and west of Saggars Hill, over bore holes 29-30-31 drilled by Nixon and Associates. The optimistic view is that blasting will be required at depths -

11 metres, Goliath Mine Area

8 metres, west of Saggars Hill

- and accessory blasting is likely at shallower levels.

Contour strip mining may be possible for an area such as west of Saggars Hill:-

Hole 28 : 14'0" to 18'4"

Holes 27,29 : oil shale about 24 feet

ie mostly rippable overburden, minor blasting.

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TABLE 7
Results of Mayhew Drilling, March-April 1975

Drill Hole	Tas shale log interval	T.M.D. core interval	Sampled interval	Yield gal/ton	Comment (basis: core observed TMD Hobart and Nixon logs)
CHINA FLAT AREA					
#4	Not observed	72'3"-76'9"	-	-	Very few spores. Hard mudstone-shale. Irregular broken fragments, 1/2" to 1 1/2" size; flakey
#5	56/57-58	58'6"-62'0"	-	-	Less than 2 ft recovered. Soft grey sandy mudstone with 1/4" quartz pebbles
#7	22'6"-25'6"	23'0"-25'6" and 26'2"-31'2"	Not recorded	6.6	Only very short section sampled and Pebbly mudstone
#8A)) 8 #8B)	27'6"-29'9" & 30'7"-32'1"	13'0"-22'1" 27'10"-33'10" combined with	- (1) 27'10"-28'5" (2) 28'5"-30'7") 31'7"-32'1") (3) 30'7"-31'7"	- 88.5 19.8 38.3 <u> </u>	Fair recovery. Uniform very fine sandy mudstone. Fissile. Few spores. Arenaceous to 28'5", then greenish grey, fine grained, with laminations of tasmanite discs. Pyritic Est 40% recovery in this section
	27'10" to 32'1" = 4'3" average weighted ..			33 gal/ton	
#11B	4'6"-5'8" & 5'11"-6'2"	4'6"-7'2"	Not recorded	21.1	Fair recovery, badly broken. Oil shale from 4'6". Log records 6'2" to 6'4" lost; 6'4" to 7'2" blue grey mudstone

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Table 7 (cont.)

Drill Hole	Tas shale log interval	T.M.D. core interval	Sampled interval	Yield gal/ton	Comment (basis: core observed TMD Hobart and Nixon logs)
#12B	51'6"-55'10"	48'4"-58'4"	(1) 50'4"-52'10" (2) 53'10"-56'8" (3) 56'8"-58'4"	(1)+(3) 22.4 33.0	48'4"-50'4" harder shale, fissile, laminated Very soft, crumbly oil shale Very rich, light brown oil shale Pebbly grey mudstone logged, but observed as oil shale. 90% recovery this section
#13B	70'7"-72'7" and 72'11½"-74'7½"	70'8½"-76'10"	(1) 70'8½"-72'11" (2) 72'11"-74'0½" (3) 74'0½"-74'5"	(1)+(3) 15.8 37.0	Log records oil shale, except last 4" pebbly mudstone. Rich oil shale Oil shale, decreased spore content
#16B	No shale	30'-35'	-	-	Very fine sandstone, soft with quartz pebbles about 30'
SASSAFRAS AREA to west of Sagers Hill (available core)					
#27B	21'2"-23'6" 23'6"-24'2" 24'2"-24'8" 24'8"-25'3" 25'3"-26'4" 26'4"-28'1" 28'1"-31'5"	21'2"-31'5"	Not recorded	22.4	Good recovery Pebbly mudstone, grading into oil shale from 23'0" Richer oil shale Mudstone, low spore content Oil shale Mudstone, low spore content Oil shale Mudstone to 28'9", then pebbly sandy mudstone

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Table 7 (concluded)

Drill hole	Tas shale log interval	T.M.D. core interval	Sampled interval	Yield gal/ton	Comment (basis: core observed TMD Hobart and Nixon logs)
#28	14'0"-18'4"	12'11"-22'11"	(1) composite 12'11"-14'0") 14'5"-15'7") 16'8"-18'4")	10.5	Good recovery; few oil spores apparent
			(2) 14'0"-14'5") 15'7"-16'8")	47.5	Selected (richer) shale intervals
#29B	23'8"-23'10½" 24'11"-26'2" 27'3"-28'3"	22-32'	Not recorded	19.8	Recovery estimated 75%
#30B	27'1"-29'0" 29'9"-30'9"	25'-34'1"	-		Not sampled. Core all jumbled from transport. Varying hardness to pug, mostly soft.
#31	96'6"/97'- 98'9" 99'6"-100'8"	No core at TMD	Not recorded	15.8	Log records 0-54 ft as soft blue grey mudstone

NOTES: Hole numbers 1 to 20 drilled at CHINA FLAT
Hole numbers 21 to 38 drilled at SASSAFRAS - SAGGERS HILL
Seismic Survey covered holes 29-30-31

Face 400 ft x 10 ft advance per day gives 1000 tons shale/day
 x 15 ft advance 1500 tons shale/day

For face 400 ft long

4'3" shale gives 100 ton shale/foot advance

Overburden per ton of shale (allow 10% for batters) is

- for 20 ft depth to shale 500 tons/foot advance
 - for 30 ft* depth to shale 770 tons/foot advance

(* probably the maximum)

say, 6.5 tons overburden/ton shale,

@\$1.00 per cubic yard

about 1.5 tons/cyd - say 65 cents/ton

Overburden	6.5 tons @ 65 cents	4.23
Oil shale	1 ton @ \$1.00	1.00
		<hr/>
		\$ 5.23 / ton

Thus, even with oncosts, shale should be mineable profitably at these depths. Open pit extraction of such thin layers will inevitably mean whole seam mining, and will need very careful monitoring of the base of the overburden to avoid loss or excessive dilution into the seam.

Nixon and Associates located shales at depths of less than 30 ft in consecutive holes 27 to 30, from which the writer infers potential for an open cut

1500 metres - 5000 feet

and 400 feet appears quite realistic, along contours, ie 500,000 tons shale.

Results of holes 7 and 8 and hole 11 on China Flat, suggest other areas of shallow open cut would develop as reserves on further drilling.

However the reserves available at this very shallow level are probably limited as a proportion of the overall reserves of shale.

Considerations of underground mining

The market for the products from a tasmanite shale oil operation will need to know that long term economic reserves exist. This means that development will not proceed to any extent until profits are seen from underground mining operations where the bulk of the known reserves exist.

Further, lengthy research and development work is not justifiable only on the basis of the inferred open cut reserves of shallow depth, as are known at present.

The approach to underground mining is to some degree dependent on whether or not selective mining is important to subsequent processings or the end product.

ie will selective mining automatically reduce the present mineral matter in the flotation concentrate, and therefore in the asphalt?

Access by decline adit appears the likely manner of entry with production transferred by conveyor belt to surface.

(i) whole seam mining

The pebbly characteristic of the seam may be critical. However, the writer understands that similar difficult and "stony" conditions exist within the coal seam as mined by Cornwall Coal, near Fingal, Tasmania where continuous miners are operating.

Assume 4'6" minimum height of stope

9 day fortnight, 200 days p.a.

One continuous miner to give max 150,000 tpa (double shift)
ie one unit gives insufficient output for 50,000 tpa asphalt
and 2 miners plus 4 shuttle cars would be required.

Capital costs are listed under General Economics, this report.

(ii) Selective mining

The old underground workings of the Goliath Mine were visited on 29 September 1975. The two northernmost adits are not accessible due to a fall of rubble at the entrance. The southern adit provides easy access to all the principal workings - open stopes/bords off a principal drive. There is minimal timber in the workings, and few falls of rock appear to have occurred since the mine closed. Open stoping to 50 ft wide is clearly possible, even though open stopes were more usually 20 ft wide at 50 ft intervals (mine drawings, 1928).

Assuming stopes 45 ft wide (and 60 ft pillar centres) with the long axis along the contour, some 15 stopes each advancing 6 ft per day would produce (200 days) about 300,000 tons whole seam per year.

ie each stope 1500 tons per year
20 tons of mid band waste per day
80 tons of selected shale per day
and each year consumes 25 acres of ore reserves for the
production of 240,000 tons oil shale.

Sequence envisaged -

- * survey/sample to establish through daily ash analyses the central mid band position. Paint outline to face
- * break out mid band across full face of stope. Use load-haul-dump vehicle to transfer mid band waste to adjacent mined out stope. Dump mid band waste as spoil heap across stope entry, to act as dam wall for subsequent hydraulic sand fill.
- * break out top and bottom shales. Use LHD vehicle to transfer from stope to principal conveyor/exit mine
- * conveyor belting to mill

Even though stopes have low headroom, the gentle dip and the nature of the ground conditions are such that simple mechanised operations appear practical. All development except ventilation would probably be within the ore horizon.

8. PROCESSING TASMANITE OIL SHALE

It seems that a number of process combinations need examination, extending over time and in conjunction with the development of and "asphalt" or "asphaltic bitumen" product. Three statements may be made:

- (1) The process will be ^{inter} independent with the product required, and as yet this product is not known.
- (2) the process will be a new development -
 - . Crozier performance shows surface retorting in fixed position, externally heated vessels to be too limited in output for this shale
 - . in-situ retorting is not practical, because of the nature of the deposit.
- (3) As an oil shale, Tasmanite shale is unusual in that the oil spores are physically separable from the shale by flotation. Development work utilising the concentrate appears limited to Manson and

Walker's approach to asphalt manufacture ie no attempt is recorded of using concentrates in retorting.

There may be merit in parallel development of both digester and retorting techniques, as the cost benefit from retorting to produce fuel oils and hot gases needed to dry concentrates and operate digestors may be favourable. Perhaps near surface and narrow seam oil shale horizons (which are otherwise not economic to selectively mine) may provide the shale source for this purpose.

Several approaches to processing have occurred to the writer, and each probably needs examination with both run-of-mine shale (at various lump size) and with flotation concentrate in various forms (eg as clinkers, or as airborne powder, etc.)

Note: Kurth found that slower heating rates in oil retorting resulted in more bitumenous residues - the bitumen component is a variable.

These approaches are:

a) Surface retorting in kilns of a rotary type

ie ends fixed, rotating barrel on slope

Heat could be applied internally - hot gases passing over concentrate in a preheater kiln, with the hot concentrate passing to an adjoining rotary kiln heated by internal flame tubes. Flame tubes passing through the fixed end wall may be designed to go to the centre of the kiln and return to the same fixed end wall for exhaust.

ie one set of flame tubes each end, with the hotter flame at the lower end

A relatively short kiln is envisaged, to suit flame tube efficiency.

Hydrocarbon gases from the retorting could be collected off the fixed end wall.

b) Application of the "in-situ" underground approach to suit surface retorting

Dump raw mined shale into a retort

Ignite top of shale

Close off top of retort, and support combustion by input of air under pressure from top of retort; - intention is to force

a burn front evenly downward. Oil freed flows downward to collector for pumping to surface.

Again, fixed or rotary kiln might be considered.

c) Variation of feed to above

Combination of flotation concentrate and raw shale may improve kiln performance.

Suggested processes (a) (b) and (c) above all result in crude oil which needs refining. The Crozier operations gave a crude oil which on refining gave the following -

Petrol	6.35
Kerosene	13.25
Diesel Oil	48.70
Tractor Oil	8.92
Bitumen	12.63
	<hr/>
	89.85
Losses	10.15 (losses in refinery)
	<hr/>
	100.00 gallons crude oil
	<hr/>

At current prices, bitumen is \$100/ton of 219 gallons plus freight, or about 50 cents/gallon. The same order of price applies to the other products in the above list, to give a net value of about \$45 per 100 gallons input - and the input to the kiln depends on the type of feed.

The point is - it may be just as profitable to extract crude oil as it is to extract an asphalt able to meet difficult specification. For this reason, oil retort design needs study as much as the Manson and Walker approach of digesting flotation concentrate needs further study.

(d) Manson and Walker have shown that asphalt manufacture is possible by flotation and digestion. Their process needs considerable developmental work beyond what was known in 1937 in order to

- . produce asphalt to specification
- . produce at a commercial rate - a bank of digestors such as the one at Latrobe does not seem practical to the writer, and with success in product design, outputs of 200 times the daily capacity of the Latrobe digester are envisaged.

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Note: The old processes were covered by patent: the status of those patents is not known.

9 GENERAL ECONOMICS

Bitumen is bought on a weight basis for 220 gals/ton
\$100/tonne is approx \$100/ton

Tasmanite asphalt (1937) contains 150 gals/ton, 50% bitumen.
Asphalt production also yields 50 gals fuel oil/ton of asphalt produced, This byproduct has value in that it roughly cancels out the approx 50 gals fuel oil needed to fire digester in the production of asphalt.

- ie asphalt on weight basis has value \$30/ton*
- asphalt on gallon basis has value \$34/ton*

(*assuming basis is on value of bitumen content only.)

However, if based on performance price could be expected to double this amount at say \$70/ton.

Road trials on asphalt at some future time may very well show savings in extended pavement life, which would then justify a higher initial product price.

- ie the characteristics of bitumen + filler may give a favourable performance as a Primerbinder, in competition with cutback bitumen or bitumen emulsions with target life six months or more. There is obvious cost benefit in a product which can extend the primer life by even 2 or 3 months (see Table 5).

Adopting \$70/ton now for asphalt

(1) <u>Whole seam shale mining</u> - continuous miner	
@ \$7/ton x 6.3 tons (as page 19)	\$44.10 cost to mine
estimate flotation @ \$3.00	18.90
	<hr/>
	\$63.00 / ton

Therefore, the present price covers mine and mill operating cost, and possibly freight, but not processing, return of capital, or profit.

(2) Selective mining

Capital costs of mine plant will be lower. Operating costs higher, as mining of Tasmanite shale must carry cost of waste rock.

Yield increased by 25%, using selected shale

∴ 4.7 tons / asphalt ton

@ \$12 / ton	\$56.40 cost to mine
Flotation at \$3/ton	14.10
	<hr/>
	\$70.50

The operating cost is higher, but the net cost is probably about the same as above due to lower capital cost for (2) above.

The conclusion is that there is at present no margin in the present prices to cover

- . processing - guesstimated at \$25/ton asphalt
- . return of capital - estimated at \$20/ton asphalt product
- . profit - @ 15% on \$115 product price = \$17/ton

Say, Tasmanite product price \$132/ton

ie a normal bitumen price of \$200/ton is needed for commercial operation, assuming that a product can be developed that is acceptable and has inherent merit that justifies a price in excess of its value by direct gallon comparison with straight bitumen.

Optimism is needed to pursue development. However, the risk is not whether or not the resource exists, but how it may be won at profit. In this sense, it is a development project which may be eligible for Government assistance to finance development, through development grants, and in that case continuation with the project must be recommended.

10

RECOMMENDATIONS

The Mines Department, Tasmania, should be approached for laboratory assistance (Launceston) to produce the samples of asphalt and bitumen needed for further comparative tests at the CRB laboratory, Melbourne.

As discussed on page 28 these are

- .a sample of 15% ash asphalt
- .a sample of 30% ash asphalt
- .a sample of retorted bitumen product

The CRB will test these products at no charge. This should indicate whether Tasmanite asphaltic bitumen has, by comparison with bitumen, any desirable or advantageous natural characteristics to justify

optimism about future product value and price.

On that basis, a decision may be made to either continue with the product, or reject it. If there is optimism to continue, then avenues for research grants or investment allowances should be explored - new rulings on investment allowances apply after January 1, 1976.

Fredrick L Hunt

F.L. Hunt

24 December 1975

APPENDIXReferences

- Anon unpub
(1) "Information extracted from local literature (10 pages)
This undated information gives a brief history of attempts to establish the shale oil industry in Tasmania, and reviews outputs from various individual company retorts.
- (2) "Investigations into the manufacture of asphalt" (40 pages)
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- Davies, T.H. (30 October 1935) Unpub letter by the then Tasmanian Minister for Mines to Senator McLachlan, then Federal Minister in charge of development. The letter is a submission for Commonwealth assistance towards the development of the process to produce asphalt from Tasmanite shale. It provides a statement of the development position at that time.
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- Nye, P.B. (1932) Within report of Tasmanian Shale Oil
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Appendix 3d - Results of the sampling of Tasmanite
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Appendix 4 - Mining Sub-Committee Reports
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the organic nature of Tasmanite shale oil over a
2 year period, to establish that in excess of 50
different organic chemicals or products could be
obtained from the distillation products of shale oil.
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