1986/61. A summary of the oil shale resources of Tasmania

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Abstract

Small deposits of oil shale in northern Tasmania have been investigated previously as a potential source of hydrocarbons or road bitumen. The shale has been mined intermittently since the 1860s. During the 1930s a number of experimental retorts were used by different companies to produce a variety of fuels and fuel products, although none of the retorts operated as a commercial success. The oil in the shale is derived from microfossil algal cysts or algal bodies, which release oils when heated. The host sediment is of marine origin. The shale is of Late Carboniferous age and is older than the Mersey and Preolenna Coal Measures, and not a facies variant thereof. Recent exploration has defined indicated *in situ* reserves of 40 million tonnes of oil shale, although no commercial application exists for the products which can be produced.

LOCATION AND ACCESS

Most of the known occurrences of oil shale are in northern Tasmania, where the oil shale crops out discontinuously along a broad belt some 48 km long which extends from Latrobe [DQ520325] in a south-easterly direction to Quamby Brook [DP765915] (Blake, 1931). The areas in which the oil shale crops out in the Latrobe-Railton district are shown in Figure 1. An isolated occurrence of the oil shale has been noted in a drill hole near Bicheno [FP045732].

GENERAL GEOLOGY

The horizon of oil shale occurs near the base of a siltstone/mudstone unit (the Quamby Group and correlates) which overlies the basal tillite of the Lower Parmeener Supergroup.

The oil shale occurs from 6-22 m above the top of the tillite at Oonah [CQ845345] , nine metres above the base at Chudleigh [DP570990], and 22 m at Latrobe (Clarke, 1968). The oil shale near Quamby Brook [DP765915] has been called the Bakes Oil Shale (Wells, 1957).

The oil shale horizon contains marine fossils, including foraminiferal faunas at Oonah and Latrobe. Spore assemblages date the oil shale as being Sakmarian (Early Permian) (Balme *in* Spry and Banks, 1962), although more recent work has determined that the oil shale microfloral assemblage belongs to 'Stage 2' (Truswell, 1978). This stage is largely considered to be Late Carboniferous in age.

The oil shale is not a facies equivalent of the Mersey Coal Measures, which is stratigraphically above the Quamby Group. The coal measures are thus younger than the oil shale.

TORBANITES - CANNEL COALS

At Preolenna and around Barn Bluff, thin coal occurs in the Lower Freshwater Sequence of the Lower Parmeener Supergroup. This interval is known as the Mersey Coal Measures near Latrobe and the Preolenna Coal Measures near Preolenna. Some parts of these coals are sapropelic, formed by concentrations of the algae *Reinschia*. These coals have been referred

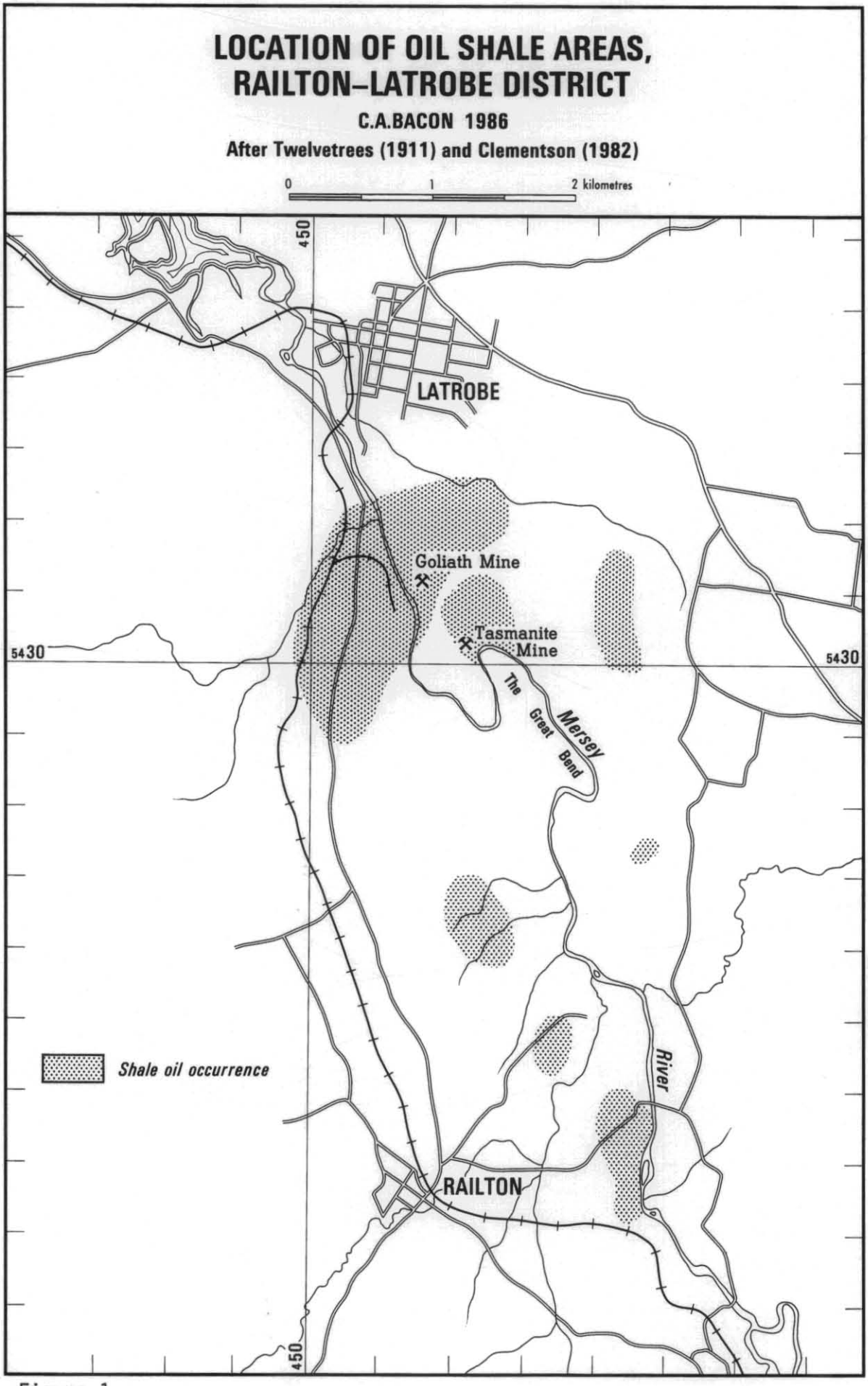
LOCATION OF OIL SHALE AREAS,
RAILTON–LATROBE DISTRICT
C.A.BACON 1986
After Twelvetrees (1911) and Clementson (1982)
0
1
2 kilometres
450
LATROBE
Goliath Mine
Tasmanite Mine
5430
5430
The Great Bend
Mersey
River
Shale oil occurrence
RAILTON
450
5 cm

Figure 1.

to as kerosene shales and sometimes as oil shales. They are, however, part of the Lower Freshwater Sequence which overlies the Lower Marine Sequence in which the oil shale horizon exists.

DESCRIPTION AND ORIGIN OF THE OIL SHALE

Twelvetrees (1911, p.4) provides a brief history of the early discovery and work on the oil shale, including extracts from early publications. In 1861, T. S. Ralph suggested that the oil shale, or dysodile as the rock was then called, was a shale containing spherical algae bodies which were preserved by their being coated "by a resinous substance".

The name "tasmanite" was coined by A. H. Church in 1864 (see Twelvetrees, 1911, p. 7). Previously the oil shale had been known by a number of names, including resinous shale, yellow coal, and dysodile. Church examined samples of the oil shale, finding that the substance was unaffected by alcohol, ether, bisulphide of carbon, benzole, turpentine and paraffin oil, and that petroleum products could be obtained from destructive distillation of the shale.

Church also stated ".....Tasmanite is believed to be the first carbonaceous material which has been found to contain in combination - not with a metal, as in pyritic coal, but in intimate union with the carbon and hydrogen of the substance ....".

The physical form of the algae bodies and sculpturing on the tasmanite sacs was described by R. M. Johnston in 1872 (Johnston, 1888, p. 139). In 1875 E. T. Newton suggested that the oil-rich bodies in the shale were lycopod macrospores and proposed the name *Tasmanites punctatus* for the bodies, and that the name tasmanite be used for the shale (Twevetrees, 1911, p. 8).

Discussion on the origin of *Tasmanites* bodies has continued. E. A. Newel Arber, in his *Catalogue of the fossil plants of the Glossopteris flora* of 1905, doubted the lycopod origin of the spores (Twelvetrees, 1909), a view shared by Singh (1932), who reasoned that the *Tasmanites* bodies shared no resemblance with living lycopod spores, and the known fossil flora of the Early Permian consisted only of gymnosperms and esquisitales, no lycopods having been found.

Singh (1932) also noticed that the *Tasmanites* bodies showed a sculptured, not punctate surface, with some having a tri-radiate mark. The spore walls were stratified. The large range in size of the *Tasmanites* was suggested as being the result of a number of closely related plants contributing spores, or alternatively a mixture of mature and immature spores would give a size variation.

The fossil *Tasmanites* is now regarded as being cysts of a planktonic algae similar to *Pachysphaera* (Cane, 1974). The deposits of tasmanite probably are described as "probable green alga" by Truswell (1978).

In hand specimen the oil shale is a blue-grey colour when fresh, but weathers to a dark yellow. The tiny *Tasmanites* can be seen as orange discs on bedding planes. Whilst there is a large range in the size of the *Tasmanites* bodies most are 300-400 µm in diameter and between 30-50 µm thick. The discs have evidently been flattened. Some spheroidal *Tasmanites* bodies have been found, the rounded shape being retained by the bodies being filled with mineral matter prior to compaction.

Associated with the *Tasmanites* are traces of the coal macerals inertinite and vitrinite. The vitrinite reflectance is low, indicating a low rank for the material (Shibaoka and Taylor, 1978).

PREVIOUS MINING HISTORY

The first record of oil shale in Tasmania was made by Milligan (1851) who described beds of "brown schist (allied to dysodile) of a highly combustible nature" cropping out on the banks of the Mersey River. While inspecting the Mersey-Don coalfields, Selwyn (1855) also examined the oil shale near Latrobe, which he called "yellow coal".

Penny (1855) examined and analysed samples of oil shale. Gould (1861) inspected small-scale prospecting activities in "resinous shale or dysodile" in the Latrobe district. Outcrops near The Great Bend of the Mersey River [DQ530290] had been opened up by quarrying in 1860. Small waterworn fragments of dysodile were also found in a tributary of Caroline Creek by Gould (1861).

A company was formed in Hobart to manufacture "parafine oil" from the dysodile found "in great quantities" near Torquay (i.e. near Latrobe) (*Examiner*, 13 March 1861). These plans did not eventuate.

The Railton-Latrobe oil shale deposits were examined at length by Thureau (1883) and Johnston (1888), who both gave detailed descriptions of the field but were unable to ascertain the actual age of the oil shale.

After some initial prospecting activity in 1860, which comprised digging one shaft and opening one quarry to expose the oil shale (Gould, 1861), interest in the field waned until 1901, when the Tasmanian Shale and Oil Syndicate of Adelaide was formed.

Messrs Esdaile and Black were engaged to examine the Syndicate's shale-bearing lands. In 1902, when the Tasmanian Shale and Oil Company NL was formed by Syndicate members, the pair were employed to conduct extensive laboratory experiments to determine the quantity and quality of oil which could be extracted from the shale, and made a number of different fuel products from the oils.

In 1908 and 1909 several shafts were sunk by a Mr Hedditch in the general area of China Flats, south-east from The Great Bend (Twelvetrees, 1911).

In 1910 the Tasmanian Shale and Oil Company NL was reformed. Four retorts were erected in the Mersey-Railton shale field, near The Great Bend of the Mersey River. They were designed by manager W.J. Hall. The operation of these retorts was described by Twelvetrees (1911, p. 63):

> "each of the retorts is supposed to treat daily 4 or 5 tons of shale, which is subjected to slow distillation, during which process the gas from the retorted shale passes into a cooler and through the condenser, and the crude oil finally flows into the stock tanks. The lighter oils and spirit having been extracted by distillation, the remainder is residual or fuel, oil. The spent shale is stacked for manurial purposes ..."

Twelvetrees (1911) inspected the workings of the Tasmanian Shale and Oil Company and visited a number of other leases held by individuals in the area. The only mine at the time was that of the Tasmanian Shale and Oil

Company, which consisted of a number of adits. The shale was mined by hand from the adits, then conveyed to the retorts after having been crushed. In all twenty tonnes of oil were produced from this operation. This mine is shown on Figure 1 as the 'Tasmanite Mine'.

The Latrobe Shale Oil Company NL was also formed in 1910. A drilling and prospecting campaign was conducted on their leases, which were on both banks of the Mersey River. Most prospecting was carried out on leases on the western bank of the river near China Flats, where a number of boreholes and shafts were sunk. A fifty tonne sample of oil shale was sent to the Pumpherston Oil Works, Scotland, where tests were made in the experimental Pumpherston Patent Retort (DOM Correspondence Files M236/1).

In 1912 another company, the Railton-Latrobe Shale Oil Company NL, took over Hall's operations. A new style of retort was tested and the four original ones (which had produced twenty tonnes of oil) were scrapped.

By 1914 there were four vertical and two horizontal retorts with an associated condensing and refining plant capable of producing 1130-1360 litres of crude oil per day. The products from this activity included motor spirit, turpentine substitute, rubber solvent, and fuel oil (Secretary of Mines Report, 1918). Insufficient capital forced the closure of this venture in 1916 (Blake, 1928).

A proposal in 1915 for Government assistance to the shale oil industry led to an inquiry into the industry by the Parliamentary Standing Committee on Public Works. The proposed investment of the State Government purchasing the property and interests of the Railton-Latrobe Shale Oil Company was carefully examined (Mulcahy, 1916), debated in Parliament, and defeated in the Legislative Council (James, 1933).

The Mersey Valley Oil Company and the Adelaide Oil Exploration Company were involved in a search for liquid petroleum in the Mersey-Railton areas during the early 1920s. Logs of their holes, which frequently intersected the oil shale horizon, are given in Reid (1924).

In 1922 Southern Cross Motor Fuels Pty Ltd erected and experimented with a Schultz retort, using shale mined from the Railton-Latrobe Oil Shale Company's lease at the northern end of The Great Bend (Reid, 1924). The company was reorganised in 1925 and continued with a MacPherson retort until 1928 when yet another company (the Tasmanite Shale Oil Company Ltd) took over. After unsuccessful trials up to 1930 with a Long retort, the old MacPherson retort was used once more (James, 1933).

Following trials of the Latrobe oil shale in retorts in Burma and in London (the latter under the control of Mineral Oils Extraction Ltd) the Tasmanite Shale Oil Company Ltd (in conjunction with Mineral Oils Extraction Ltd) set up a Crozier retort in 1932. This seems to have been the most successful of all the retorts tried in the Railton-Latrobe field.

In 1922 the Tasmanian Cement Company was formed and developed an interest in oil shale, proposing to use the shale as a fuel and the spent shale as an additive during the manufacture of cement (Reid, 1924). A mine was opened one kilometre north-west of the Tasmanite Mine on the eastern bank of the Mersey River and a retort erected at the cement works at Railton. The retort was designed to distil oil from the hot gases from the combustion of the shale used in the cement plant. The retort was designed by Mr Stone, the superintendent of the cement works.

A short branch railway line was constructed from Shale Junction on the Western Line towards the Mersey River, with sidings at Shale Bins (later renamed Shale Siding) and Bronder (later renamed Elandon). The line was in use by March 1925, with the timetable allowing for the regular movement of fifteen seven-ton wagons of shale per day between Shale Bins and the Tasmanian Cement Company's siding near Railton.

In 1928 the company was reconstructed as the Goliath Cement Company. The retort designed by Stone was not a success and further tests were made in the Crozier retort run by The Mineral Oils Extraction Company.

Bronder retorts were erected by the Australian Shale Oil Company in 1925; this company was taken over by L and N (Tas), then by the Shale Oil Demonstrating Company, which erected a Scotch (Pumpherson) retort in 1933, which was operated for a short time.

In 1931 a Shale Oil Committee was set up, with members from the State and Federal Governments and from industry. One of the first recommendations of the Committee was that the various interested parties in the Railton-Latrobe oil shale field should amalgamate into one company. The Tasmanite Shale Oil Company, Goliath Cement Company, Mineral Oils Extraction Ltd, the Railton-Latrobe Shale Oil Company and F. Richards combined to form one company known as the Tasmanite Oil Shale Company. Only the Shale Oil Demonstrating Company decided not to amalgamate (DOM correspondence files) and continued on their own, experimenting with a Pumpherson retort in 1935 for a short time. Following the amalgamation, the State Government made available funds towards the cost of experiments with the Crozier retort.

The Tasmanite and Goliath Mines were sampled thoroughly in 1931 (Blake, 1931) and the samples analysed at the Department of Mines Laboratory, Launceston (Nye, 1931). The ash, sulphur and specific gravity of each sample were determined. The oil yield of the samples was deduced from the ash content of the shale by means of a graph produced after years of experimentation by Mr Kurth (Nye, 1931). A summary of Kurth's work (1931-1933) is given in James (1933).

During the investigation of the Shale Oil Enquiry Committee in 1932, the Department of Mines conducted a short boring campaign, drilling six holes near the Goliath and Tasmanite Mines (Nye, 1932). Plans were drawn up for a comprehensive drilling programme to thoroughly examine the oil shale areas (Nye, 1932).

Two grants of 1000 pounds ($2000) and 500 pounds ($1000) were provided by the Commonwealth Government for this work (Nye, 1933, 1934). Cores were analysed in the Department's laboratory and oil yields determined from the relationship of ash content/oil yield as established by Kurth. In all, sixteen holes were drilled (Nye, 1934; Hughes, 1935), with drilling finishing in 1935. The Shale Oil Committee also investigated the feasibility of the oil shale being used to produce bitumen.

Experiments were made in 1931 and 1934 to produce a spore concentrate by grinding the shale and subjecting the powder to froth floatation to float off the organic *Tasmanites* bodies (Walker, 1937). Various floatation cells were used in 1934 with varying degrees of success. The spore concentrate was used in experiments to manufacture bitumen. Kurth presented to the Committee several samples of bitumen produced from the shale by a process of very slow distillation. This process, which was different to that used to extract oil from the shale, gave by-products of oil and gas in small

quantities. The Committee concluded that neither an oil distillation plant nor a bitumen producing plant would be able to operate on a profitable basis. If either venture went ahead, the committee recommended that the operating loss be regarded as a form of unemployment relief (Nye, 1934; James, 1933).

The Crozier retort, which had been operating with the help of Government subsidies, ceased working in January 1935. However interest continued into the possibility of asphalt or bitumen production. The Department of Mines set up an experimental eight-cell flotation plant at the Launceston laboratory to experiment with the separation and concentration of the organic fraction of the oil shale. Asphalt was produced from the *Tasmanites* concentrate by subjecting the concentrate to low heat. Small quantities of oil and gas were produced as by-products of this process.

The asphalt was tested in Launceston by the Department of Public Works and found to be "equal in all respects to imported bitumen". The siliceous residue from the floatation process was found to be valuable as a "filler" in road surfacing (DOM Annual Reports, 1935; 1936). The results of these experiments are detailed at length in Walker (1937).

In 1937 the oil shale occurring near China Flats was sampled thoroughly and examination was made of the various shale-bearing areas to determine the extent of the shale and probable faulting. A number of sections were drawn and reserves estimated for the areas around the Goliath and Tasmanite Mines, North China Flat, and South China Flat (Blake, 1937*a*, *b*).

Also in 1937 preparations were made to build a pilot plant digester at Latrobe to produce bitumen from the spore concentrate produced at Launceston. Twenty tonnes of concentrate had been made for this purpose. The pilot plant was completed in 1939 and produced a quantity of bitumen and oil. Following the success at converting the concentrate into bitumen, plans were made to install a commercial-sized operation (DOM Annual Reports, 1937 to 1939).

Plans were also made to further define the areas of oil shale and a number of holes were drilled in 1940/41 to prove up the extent of the deposits (DOM Annual Reports, 1940; 1941). The fifteen holes were drilled in the vicinity of the Goliath and Tasmanite Mines, near The Great Bend [DQ520305].

Endeavours were made in subsequent years to find a commercial application for the production of bitumen. In 1945 evidence was submitted to the Commonwealth Public Works Committee on the extraction of oil by straight retorting from the Mersey Valley oil shale and on the production of bitumen and by-product fuel oil from the oil shale concentrate by heating.

Interest in the oil shale was revived when an exploration licence was taken out in 1974.

RECENT EXPLORATION

Extensive investigations into the chemical nature of the crude tasmanite oil and distillation fractions were made from 1939 to 1968 (Cane, 1941; 1968).

An exploration licence over the area of the Latrobe-Railton oil shale deposits was granted in 1974 to Endeavour Resources Ltd. Forty-six holes

were drilled in 1975 in and around areas in which oil shale was known to occur. The results of this exploration are detailed in Nixon (1975).

In 1974-75 the Department of Mines evaluated the feasibility of producing an oil shale concentrate by means of grinding and froth floatation. The aim was to produce a low ash spore concentrate with a subsequent high yield of oil.

Investigations were made into upgrading the spore concentrate initially produced by froth floatation at the old (1930s) pilot plant at Latrobe. Samples of the old concentrate were re-ground and re-floated, with the result that some siliceous material was removed from the *Tasmanite* bodies, producing a better concentrate (Rhodes and Wellington, 1977). Experiments were also made on producing a spore concentrate from whole rock specimens (Austin and Wellington, 1977).

In 1981/82 an Endeavour Resources/CRA Joint Venture partnership drilled two additional holes (Clementson, 1981) with the result that an inferred reserve of 40 million tonnes of oil shale was defined in eight separate areas.

Since the mining activity in the Latrobe-Railton oil shale field ceased, a number of uses for the oil shale have been investigated. At the time of mining, the shale was used as a source of liquid petroleum products, which were extracted from the shale by retorting and fractional distillation.

Subsequent investigations have researched the possibilities of the oil shale being used in the manufacture of road bitumen, reclaim rubber, petroleum coke, liquid hydrocarbons, and anode carbon, with the most promising of these potential uses to date being bitumen production.

Recent laboratory investigations are detailed in Shibaoka and Taylor (1978), Telfer *et al.* (1979*a*, *b*), and Telfer (1979).

QUALITY

Oil was extracted from the oil shale by 'retorting'. Crushed shale was slowly heated in a closed container, causing the organic fraction of the shale to decompose. Gases drawn off from the retorting chamber were passed through coolers and condensers. Various products could be extracted during different stages of the distillation process. A number of different retorts were tried in the Mersey Valley field, some internally heated, others externally heated, with varying degrees of complexity of design. The products distilled from the oil shale included kerosene, petrol, diesel, fuel oil, bitumen and turpentine substitute. The spent shale was used as a soil conditioner. Analyses of the oil shale are given in Table 1.

In the areas of the two mines the oil shale has been extensively sampled (Blake, 1931). The oil shale horizon consists of three bands; the upper and lower bands of shale separated by a middle band of mudstone. All three bands contain spores or *Tasmanites* bodies, but the quantity of spores varies between the three bands. The middle mudstone band contains the fewest number of *Tasmanites* bodies and consequently has the lowest oil yield. The top shale band contains more spores than the bottom shale, and has the highest oil yield.

Table 1. ANALYSES OF OIL SHALE

	Moisture (%)	Volatiles (%)	Fixed Carbon (%)	Sulphur (%)	Ash (%)	Crude oil yield (*l*/t)
1	2.16	20.41	5.50	0.73	71.20	-
2	2.30	36.51			61.19	-
3						245.67
4						44.37
5						122.30
6						150.61
7	0.8	30.84	5.86	2.56	62.5	192.36
8	1.0	30.00	6.20	1.92	62.8	183.31
9	1.9	16.28	8.50	1.26	73.32	
10	1.3	22.86	5.84	1.65	70.00	130.04
11				2.61		117.29
12				2.65		148.96
13				2.77		130.26
14				2.90		172.22
15		17.42	3.80		79.7	139
16		16.33	1.95		81.7	151

1. sample from Mersey Valley, 1850 (Penny, 1855)
2. sample from Mersey Valley tested at Museum of Practical Geology, London, 1862 (Twelvetrees, 1911).
3,4,5 sections (top, middle, bottom bands) worked by Latrobe Shale Oil Company (sent to Pumpherston Oil Works, Scotland) (DOM Correspondence Files).
6. average oil yield of seam worked by Latrobe Shale Oil Company
7. average of samples from Latrobe (Blake, 1928).
8. average of samples from Railton (Blake, 1928).
9. sample from Nook (Blake, 1928).
10. sample from Barnett Creek (Blake, 1928).
11. whole seam average, Goliath Mine (Blake, 1931).
12. top and bottom shale average, Goliath Mine (Blake, 1931).
13. whole seam average, Tasmanite Mine (Blake, 1931).
14. top and bottom shale average, Tasmanite Mine (Blake, 1931).
15. average of samples from North China Flat (Clementson, 1981).
16. average of samples from South China Flat (Clementson, 1981).

Table 2. SAMPLING RESULTS OF TASMANITE SEAMS

	Thickness (m)	Specific gravity	Sulphur (%)	Oil yield (average) (*l*/t)
Tasmanite Mine				
top shale	0.58	1.9		198.16
middle band	0.41	2.45		38.47
bottom shale	0.55	2.03		146.27
average	1.54	2.09	2.77	172.22
Goliath Mine				
top shale	0.61	2.0		162.38
middle band	0.37	2.5		32.21
average	1.59	2.15	2.61	148.96
whole field			2.65-2.69	153.74

Over the Latrobe-Railton field the oil yield of the whole seam is around 153-165 litres per tonne (34-37 gallons/ton) of crude oil. The seam is about 1.53 m thick, with the poorly yielding middle band being 0.30 m thick. The overall sulphur content is 2.7%, and the shale has a specific gravity of 2.0 (Blake, 1931).

Analyses from more recent exploration in 1981 gave a range of oil yields from 109 to 177 litres per tonne, with an average yield of 143 litres per tonne (Clementson, 1982)

RESERVES

The oil shale has been found in a number of areas, although most occurrences are in the Mersey Valley, between Railton and Latrobe. Reserves have been estimated as follows (Blake, 1931):

AREA	RESERVES (million tonnes)
Latrobe-Railton-Kimberley	30
Beulah	3
Quamby Brook	3
Nook	0.8
Oonah	6

The reserves are regarded as having, at best, an indicated *in situ* status. Recent exploration in the Latrobe-Railton area has resulted in defining indicated *in situ* reserves of forty million tonnes in eight separate localities (Clementson, 1981).

FUTURE POTENTIAL

Because of the relatively small reserves of oil shale, the potential for future development is limited, although some possibility exists that a commercial use for the oil shale or derivatives of the oil, such as the production of bitumen, may be found.

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