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Eagle Nickel

Report for Tasmanian Oil Shales Resource Review

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1. Introduction

Eagle Nickel Limited (Eagle) recently acquired oil shale assets in Tasmania. Previous leaseholders have neither undertaken resource estimation nor characterisation studies. Eagle requires an understanding of information available in the public domain to assist in planning for resource development.

Eagle Nickel engaged GHD to undertake a public domain literature search to identify material relevant to Tasmanian Oil Shale deposits, in particular deposits of Railton and Oonah. The information gained from this desktop search should aid Eagle in considering commercialisation of their oil shale resources in Tasmania.

The path to commercialisation of a resource includes the stages of:

1. Acquisition and review of previous work carried out on the resource.
2. Defining the resource through a drilling program to determine the extent of resource and then characterising the samples to determine grade and other properties.
3. Identifying the options available to commercialise the resource and conduct an options selection study. .
4. Carrying out pre feasibility and feasibility studies of the preferred option(s) to reach a final investment decision.
5. Engineering, Construction and Operation.

This report addresses the initial stage of commercialisation.



2. Tasmanian Oil Shale Resources

2.1 Oil Shale

The term oil shale is a misnomer as the oil bearing rock is neither oil nor shale. It is a sedimentary rock that contains an organic substance known as kerogen. Kerogen is a solid hydrocarbon of indeterminate composition, that on the application of heat, releases oil and gas. Kerogen is built into the matrix of the rock and is often an integral part of the shale. Kerogen in oil shale is formed by organic matter (plants, animals, algae).

Most Tasmanian shales (Tasmanite of the Latrobe, Railton, Cam River, and Oonah) are algal shales that are classed under a special category of torbanites. Tasmanite is more coal like rather than traditional oil shale.

Literature does not have a fixed definition for oil shale or coal. Generally, coals are those minerals that have a calorific value between 20 and 32 MJ/kg and relatively low ash content. Oil shale on the other hand has low calorific value between 5 and 8 MJ/kg and relatively high ash content (greater than 65%). Owing to the similarity between oil shale and coal similar methods of characterisation are used.

Oil shale is characterised by Modified Fischer Assay (MFA) and ultimate analysis. MFA corresponds to Proximate Analysis for coal, but contextualised for oil. It reports the bound moisture, ash content, gases and oil. The amount of oil released per dry tonne of shale is known as the Grade and has units of litres per tonne (metric) or gallons per ton (American). Typical values for Australian shale range from 50 to 600 litres per tonne. Most Tasmanian shale has an average of about 130 litres per tonne.

Another way of characterising oil shale is the Rock Eval Pyrolysis (REP). REP reports S1, the amount of free hydrocarbons (gas and oil) in the sample on a mg/g basis (a value greater than 1 is indicative of oil); S2, the amount of hydrocarbons generated through thermal cracking (quantity of hydrocarbons that the rock has potential to produce); S3, the amount of carbon dioxide produced during pyrolysis; T_{max} , the temperature at which the maximum release of hydrocarbons occurs. Other useful information that comes from the REP is the Total Organic Carbon (TOC), the Hydrogen Index (HI), Oxygen Index (OI), Production Index (PI) and Pyrolyzable Carbon (PC).

The amount of oil in oil shale is not the only measure that is important; free moisture associated with the shale is also a very important factor. The processing of oil shale will require this water to be removed and some post processing may be required. This not only adds to the cost of infrastructure but also to the overall energy requirements.

Oil shale also contains other elements, notably sulphur and nitrogen that report to the oil, gas and char on processing. Small amounts of heavy metals may also be present.

Every non-hydrocarbon present in the oil shale represents a potential process and energy cost. It must also be understood that the shale oil from oil shale needs to be further processed in a refinery in order to get traditional refinery products such as diesel and gasoline. Other issues associated with oil shale could include mining and ash disposal (if shale is removed from the ground).

Shale oil and refined products need not be the only commercial avenue for oil shale. Energy (combustion) or export (if suitable buyer) to other facilities are options that may also be considered.



Depending on the location of the resource and accessibility, mining costs can be as high if not greater than 30% of an oil shale-to-liquid facility. The three main parts of an above ground oil shale-to-liquid facility are mining, processing and refining each representing about a third of the costs.

Oil shale is a potential energy alternative. It is worth mentioning the technology development occurring in Australia and elsewhere not only for shale to oil but for shale to other products including energy. Eagle may be able to leverage off some of these technologies as they mature.

A sizeable body of information exists on Tasmanian oil shale. This information has been created by the efforts of the Tasmania Government from the time shale was first developed in the late 1800s. Other contributors to the information resource were oil shale companies like the Tasmanian Oil Shale Company; all the early companies no longer exist.

The Report to the Tasmanian Government in 1926 by Nye [4] identifies a number of oil shale locations in Tasmania that include Latrobe-Railton, Kimberley, Merseylea, Beulah, Oonah and other areas. Many of the mentioned areas are within the modern Railton and Takone projects. Blake in 1928 [5] states that oil shale is found in northern Tasmania, west of the Tamar River up to Stanley in a band that is about 30 km wide.

There is no validated information on resource size including Oonah, Railton and Preolenna. Some characterisation information is available.

The best known resources are the tasmanite occurrences along the Mersey River. These extend in south-south east direction from Latrobe. The resource that has been the subject of the most study is the Latrobe resource. This well-characterised resource is currently controlled by Boss Energy.

Eagle has interests in two projects, the Railton Project and Takone Project. The Takone project is focussed on the Oonah deposit.

2.2 The Railton Project

Figure 1 depicts the extent of the Railton tenement.

This tenement comes under Exploration License EL 15-2008. It has an area of 88 square kilometres. The Railton tenement is bounded on the north by the Latrobe project currently controlled by Boss Energy. Figure 2 depicts the possible locations of oil shale in the Latrobe and Railton tenements.

It is worth noting that there are oil shale occurrences under the basalt formations. While only two locations are indicated as "known" deposits, there is a possibility of more occurrences. Possibility of the seam extending from the Latrobe resource into the Railton resource cannot be ruled out.

The Latrobe tenement has been extensively studied and characterised by the Tasmanian Government and previous operators over several years. There has been an oil shale processing operation based on Latrobe Oil Shale. Limited information is available regarding the various parts of the resource.

Merseylea which is within the lease boundary is reported to have a probable reserve [4] (1926 estimates) of 4.5 million tonnes; Kimberley that is just outside the lease boundary (less than a kilometre) is stated to have a probable resource of over 2 million tonnes; Beulah is reported to have a probable reserve of over 1.4 million tonnes. Beulah would most probably include Lower Beulah as well. The geological map in Figure 2 shows shale occurrence between Weegenia (south east corner of lease) and Lower Beulah. A *"Permo-carbonaceous shoreline can be traced from Kimberley to Beulah but the continuity of the*

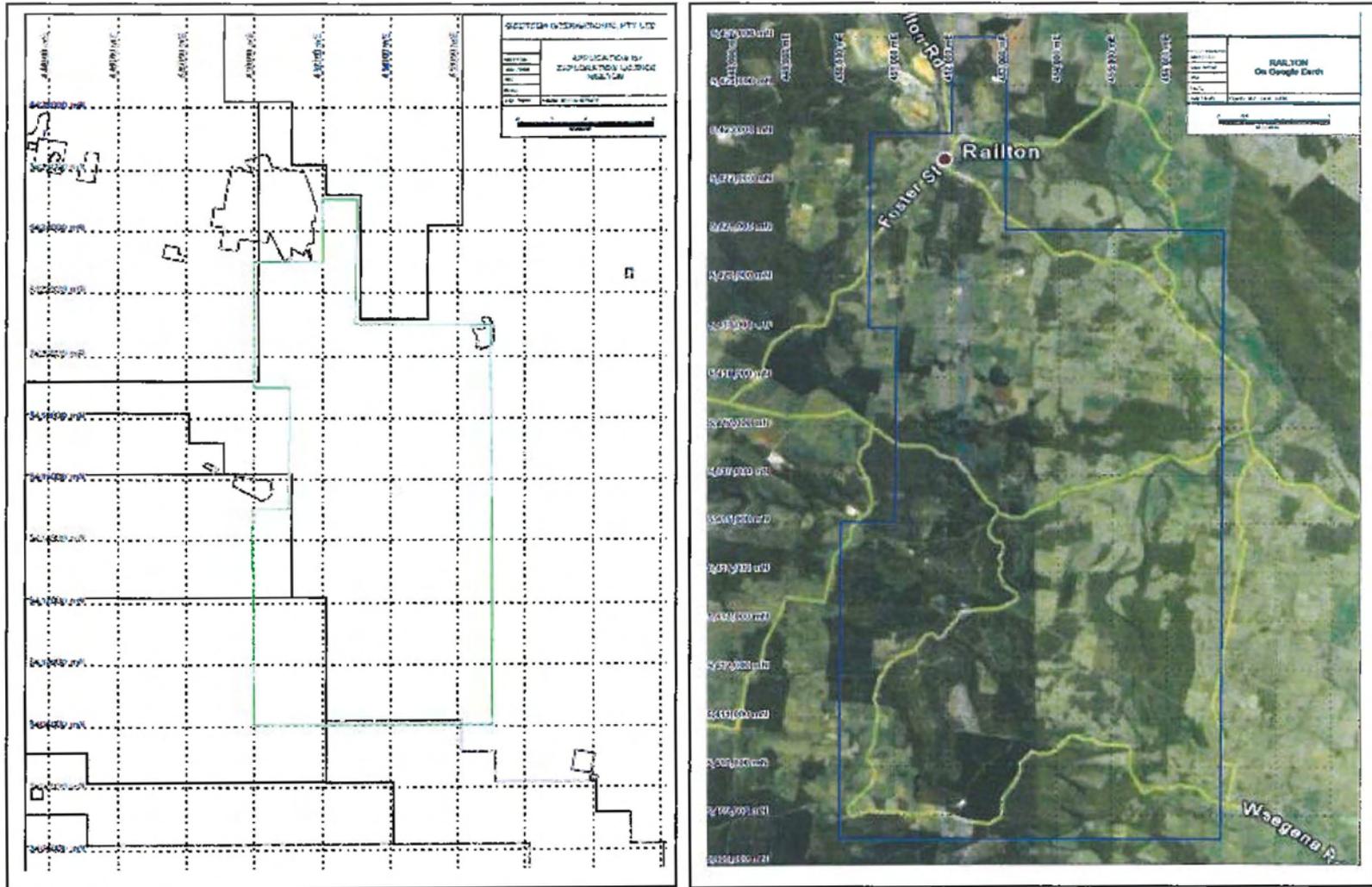


Figure 1: The Railton Tenement (source: Black Gold Resources, 2009)

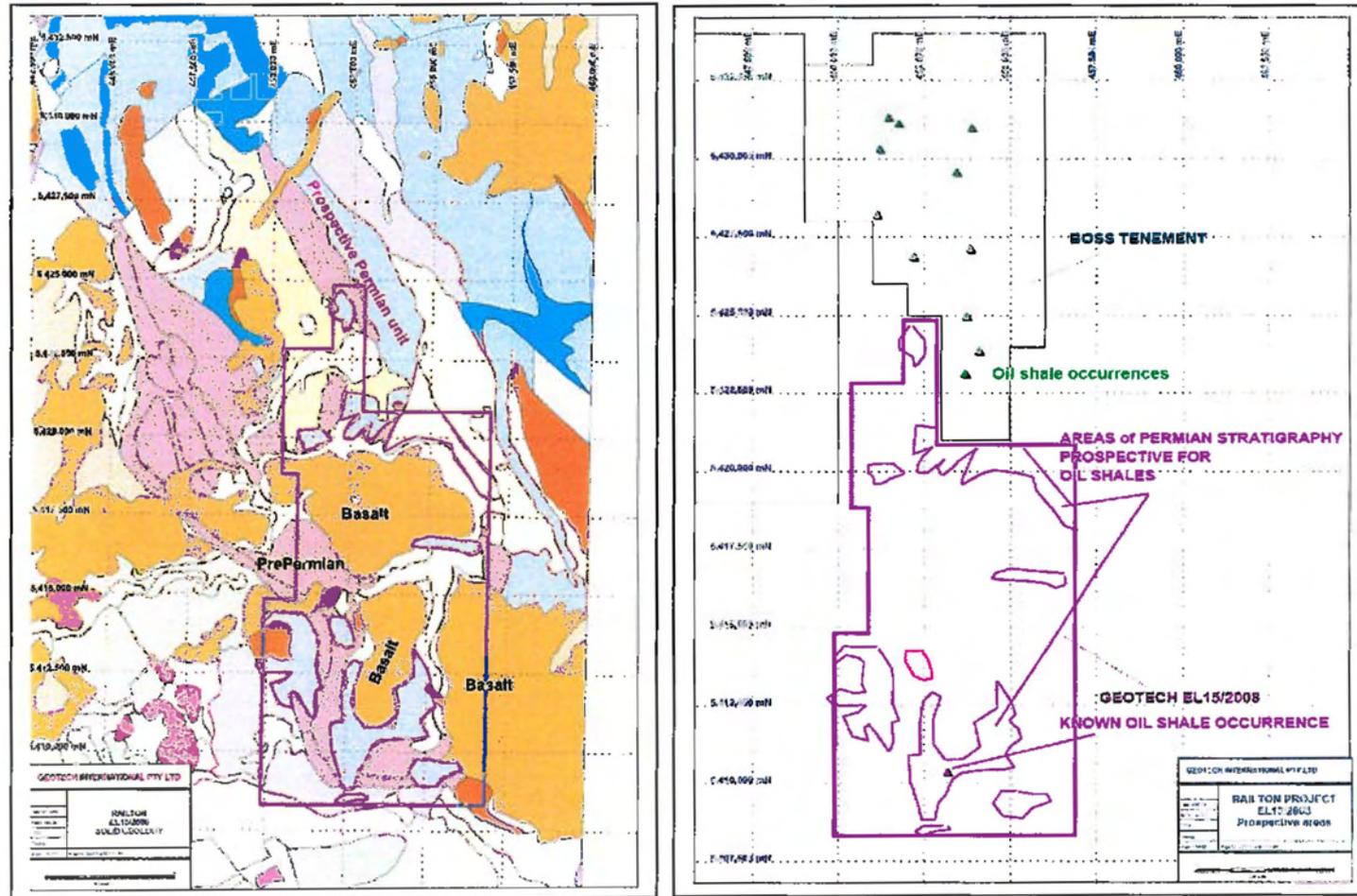


Figure 2: Geological map of the Railton Tenement (Source: Black Gold Resources, 2009)



Tasmanite is broken by faulting [2]. This suggests that shale may be present in line to Beulah (Lower Beulah), but difficult to mine.

Eagle's tenement is directly south of the Boss tenement and therefore one might speculate that the oil shale seam at the southern end of the Latrobe tenement may extend into the Railton tenement. It has also been observed from some of the early geological studies that there could be shale seams below the basalt outcrops.

The Boss tenement is estimated to be about 72 million tonnes (www.bossenergy.com) over an area roughly equivalent to the Railton tenement. However, 40% of the Railton tenement is covered by basalt outcrops. Applying a simplistic proration the Railton tenement may contain region in the region of 20 million tonnes of oil shale.

A true estimate can only be obtained through a structured drilling and sampling program.

The Railton tenement appears to have some potential. Locations within the lease have been estimated by previous studies (early to mid 1900s). Probable resources based on 1926 reports suggest probable reserves of about 7 million tonnes [4], however another report in 1928 suggests an estimate of 30 million tonnes [5].

Eagle could consider a drilling program in the Railton tenement to estimate their resource. Understanding their resource is critical to resource development.

2.3 The Takone Project

The Takone project located South of Wynyard, the main port for the region. Historically, the Takone region includes:

- Oil Shale at Oonah
- Oil Shale at Preolenna
- Coal at Preolenna
- Oil Shale at Cam River

South of Takone is the Oonah deposit, Preolenna is to the north west of Takone and Cam River to the west.

The Takone Project is based on Exploration Licence EL 73-2007 that has been issued for oil shale exploration at Oonah.

In the interest of completeness, all the named resources in the region including Oonah are briefly discussed here.

The area of the Preolenna coal field is about 2 miles by 1 mile aligned along a north-east axis. Coal seams vary in thickness from 9 to 24 inches, the majority of the seams between 15 and 24 inches. There are several occurrences of oil shale (called "kerosene shale") at various places. The oil shale does not exist independent of the coal. Observations suggest that the oil shale is a rich oil shale belonging to the class of torbanites. There is however no information on the quantity of this resource. A 1928 report [5] states that this deposit is small. Figure 3 below provides a snapshot of the location of the Preolenna deposit.



The Cam River Tasmanite field is close to the Oonah deposit. It consists of *two areas one near the point of confluence of the eastern branch with main stream; and the other larger one four miles west of it.* Again the size of the deposit is not mentioned but it is small. It is interesting to note that this deposit is similar to the Railton deposit in characteristics.

The Oonah Deposit was discovered in 1923. The conclusion of Henderson [1], the field geologist in 1944 has stated that *"the limits of this basis are very indefinite, and in view of the paucity of information no attempt should be made to indicate possible reserves."* He goes on to state that this deposit *"did not possess features that might render its commercial possibilities more attractive than any other known Tasmanian oil-shale field."* Shale characterisation based on four grab samples reported a grade that ranged between 5 and 21 gallons per tonne (20 to 90 litres/tonne) [1]. Blake on the other hand [5] suggests an average of 40 gallons per tonne (167 litres per tonne). The size of the deposit has been estimated to be 6 million tonnes but there is no supporting evidence to back this number. Figure 4 shows the location of the Oonah deposit.

The deposits are spread out and small, and there is limited information on characterisation.

The conclusion of the Tasmanian geologists regarding Oonah and Preolenna is that the resources are too small and difficult to extract to be economically viable.

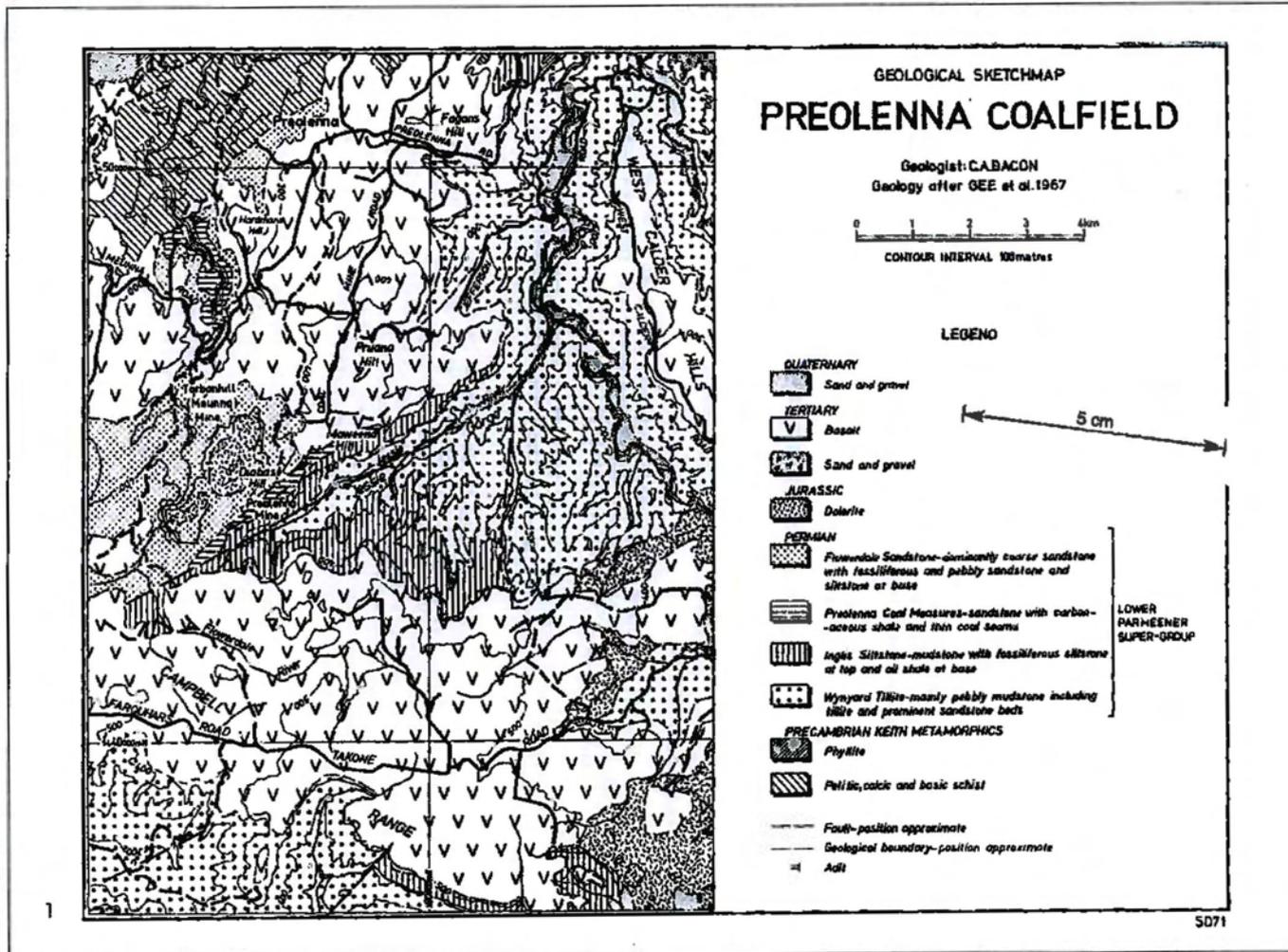


Figure 3: Preolenna Coalfield showing oil shale deposits (Source: Black Gold Resources, 2009)

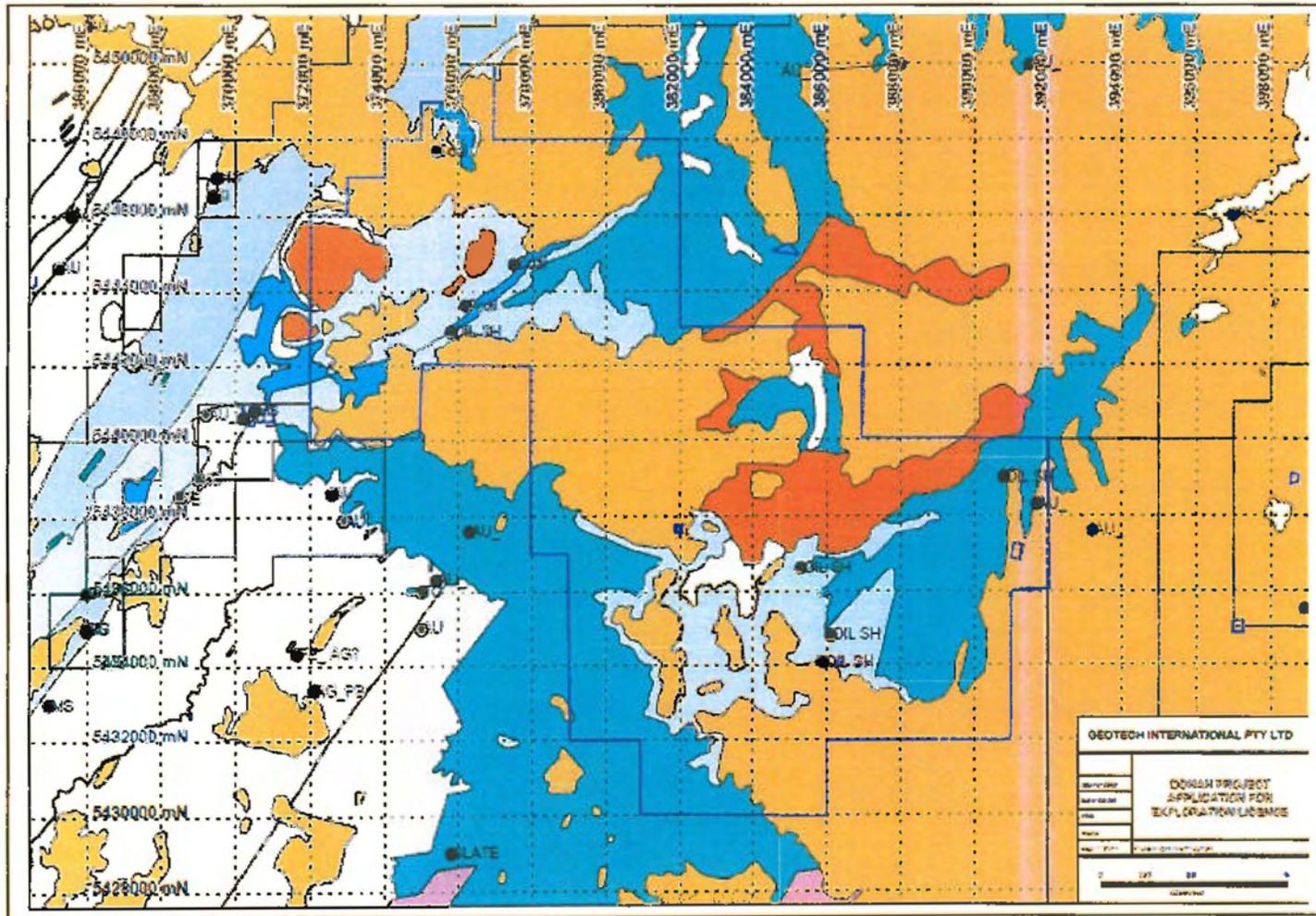


Figure 4: The Oonah Project (Source: Black Gold Resources)



3. Bibliography

Information that is most relevant and bears some authority is housed in the archives of the Tasmanian on their website <http://www.mrt.tas.gov.au>. A number of documents were downloaded (over 1000 pages of information) from this site and only the most relevant documents are listed below with a short note on their relevance (a thumb drive containing all the downloaded references will be provided separately). Unfortunately, unlike the Queensland and US shales, there are practically no academic (university or similar) studies on the oil shale resources specifically.

It is also worth noting that information on Tasmanian oil shale resources is biased towards the Latrobe resource. This may be due in part to its accessibility and early work on processing this resource. The Latrobe resource is a particularly well characterised and understood resource.

1. Esdaile, T., (1901), "Interim report on the Latrobe oil shale resource", Tasmanian Shale & Oil Syndicate, Adelaide
The main finding of the report is that Latrobe oil shale is of very good quality reporting an average return of 25.6% of crude oil and 9.1% of gases. The author was engaged to perform a number of laboratory tests to characterise shale and products from its processing.
2. Reid, A. M., (1924), "The Oil Shale Resources of Tasmania, Geological Survey Mineral Resources No. 8, Vol. I", Department of Mines, Government of Tasmania
This is a seminal document and considers all aspects of oil shale at the time of the report. It provides some detail on the extent of the resource held by different companies. Oil shale characterisation has also been reported.
3. Director of Mines (1926), "The Oil Shales of Tasmania", Report to the Department of Mines
This document presents a historical perspective on oil shale in Tasmania. The focus is on Tasmanite and the known resources of Latrobe. It mentions that the seam runs through Railton.
4. Nye, P. B. (1926), "The Oil Shale Deposits of Tasmania", Report to the Tasmanian Government.
This short report in 1926 has listed the major deposits in Tasmania. Kimberley, Merseylea and Beulah that are all part of the Railton deposit are listed as having probable reserves of 2.026, 4.5, and 1.49 million tonnes of oil shale. It also gives a probable reserve for Latrobe-Railton at 6.26 million actual reserves.
5. Blake, P., (1928), "Oil Shales", Report to the Tasmanian Government
Key statements in this report – Tasmanite has been found in the northern portion of Tasmania fronting the coast thirty miles wide and extending from the Tamar river to Stanley. The most important deposit extends from Latrobe in a south easterly direction to Quamby Brook. At Railton and Latrobe the seam outcrops. This document also mentions the Cam River oil shale deposits. It briefly mentions the Preolenna shale deposits occurring in two poorly defined 1000 acre lots. The proximate analysis of Latrobe and Railton oil shale is similar but the Latrobe resource has higher sulphur content. This report puts the Oonah resource at 6 million tonnes, however, there is no basis for this figure.
6. Australian Shale Oil Corporation (1929), "Boring at Latrobe", Report to the Tasmanian Government
It lists the various bores drilled and the depth at which shale was found.



7. Field Geologist, (1941), "Preolenna Coal and Oil Shale", Memorandum, Report to the Department of Mines
This document provides dimensions to the coalfield area stating it to be 2 miles by 1 mile along a north east axis. The main findings of the report was that the material was a cannel coal (similar to shale torbanites, the boundary is indistinct). The proximate analysis showed oil content of 130 gallons per ton. The author feels that over a period of time this could be less than 100 gallons per ton. The number is still quite high. Owing to the small area (2 square miles) and small size, the author felt that it may be uneconomical.
8. Henderson, Q., J., (1944), "The Oonah Tasmanite Oil-Shale Field", pp 43-45, Department of Mines Report
This three-page report is one of the only documents that is particular to Oonah. It states that the resource was discovered in 1923 and this document reports on a preliminary examination of the deposit to *assess the amount of prospecting required to establish the extent, seam thickness and oil yield*. The reports states that much block faulting has occurred and it would not be possible to obtain stratigraphical thickness without detailed mapping. The conclusion made by the geologist is that the seam is *too thin and yield too low to anticipate any productive possibility on a commercial scale*.
9. Twelvetrees, W. H., (N/A possibly 1940s), "Report on Shale Deposits in Tasmania"
The proximate analysis of Preolenna shale has been reported (Fixed Carbon -21/23.2; Gases – 76.2/71.6; Ash – 2.3/4.1; Moisture – 0.5/1.1). Such a composition suggests coal; this composition is similar to the Alpha shale deposit in Queensland. Again the comment is the lack of profitability owing to its distance from Wynyard and the small size of the deposit.
10. Gee, R. D. (1977), "Geological atlas 1 mile series. Sheet 28 (8015N), Burnie", Explanatory Report, Department of Mines Tasmania
This report provides information on the Preolenna coal deposit but no estimate on quantity. Oonah gets a mention but the author has stated the 1944 report by Henderson [1] that the deposit is of no economic importance.
11. Oil Shale Technology Staff, Office of Technology Assessment Materials, US Government; (1980), US Government Reports, US Government Publication, NTIS order #PB80-210115.
This report is a standard reference for any oil shale study, and although not directly relevant to the Takone or Railton oil shale projects, it is valuable information. It assesses technologies available in the US at that time. It explains the process of extraction for various technologies, and provides good background on the major technologies at that time such as Paraho and PetroSix. The sections on Environment, Water and Socio-Economic issues are particularly relevant in that these issues are important to be understood and appropriately resolved. The document provides some quantitative information on emissions for specific processes. Some of the processes that have been discussed in this document are still being considered today. Examples are the Petrosix and Paraho Processes.
12. Dyni, J. R., (2003), "Geology and sources of world oil-shale deposits", *Oil Shale*, Vol 20 (3), pp 193-252.
Although this paper is dated it covers most of the major deposits of the world, and puts the Tasmanian resource in perspective. The author has lumped the deposits around the Mersey River into a single entity.



13. Reid, C., (2004), "Petroleum System Modelling Onshore Tasmania: the Tasmania Basin – Gondwanan Petroleum System – **Final Report**", School of Earth Sciences, University of Tasmania

This report is a detailed academic study of the Tasmanian Basin. Four samples from the Oonah deposit are reported to have a Hydrogen Index between 675 and 937 indicating marine algal origin. The free hydrocarbons vary between 11.4 and 30.8 for the four samples indicating oil show. The hydrocarbon generating potential is high ranging between 54.4 mg/g to 590.8 mg/g. The thickness of the seam is 0.45 metres and this is too thin. In conclusion, Oonah shale is of very good quality, but plagued by geological and location constraints.

14. US Dept. of Energy, (2007) *Secure Fuels from Domestic Resources*, "The Continuing Evolution of America's Oil Shale and Tar Sands Industries", *US Government Report*

This document provides a listing of the major technologies available in the US for extraction of oil. The usefulness of the document is that it is a relatively recent compilation (2006) and provides a high level summary of the processes. It also provides contact details of the technology providers. The document represents a rethink of alternative technologies for utilising their vast shale resources