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Estimating the Undiscovered Petroleum Resources of The Tasmania Basin

By Tony Collings: Geologist, Great South Land Minerals Ltd.
June, 2008.

Summary:

Past estimates of the undiscovered prospective petroleum resources onshore Tasmania have indicated that up to 2.6 MMM bbl's could have been generated, with estimates based on the generative potential of source rocks (SPI method) (see table 1). Monte Carlo simulations of reservoir volumes within leads and plays are widely used in the hydrocarbon exploration industry. In this report we have used Monte Carlo simulations to generate cumulative frequency plots and to estimate the undiscovered resource potential of the basin.

Introduction:

The **undiscovered, estimated prospective** oil resource potential of the Tasmania Basin will be calculated using standard oil industry quantitative methods (adapted from: Morton, 1996b). The Tasmania Basin is a potential on-shore oil and gas producing province located in the south-eastern corner of the Australian continent. The Tasmania Basin covers an area in excess of 30,000 km^2 and is clearly oil prone due to the presence of independently verified seeps. The Tasmania Basin and specifically Great South Land's oil exploration tenement SEL 13/1998, has had over 1300 line kilometres of 2D seismic shot and processed with detailed interpretations completed. In addition to the seismic acquisition program: regional/local magnetic and gravity surveys have been performed.

Many recent studies have estimated the in-situ, recoverable oil potential of the Tasmania Basin based on the generative potential of source rocks (table1). Burrett (2004) used the Source Potential Index method (or Cumulative Hydrocarbon Potential) based on rock-eval and thickness data (Hunt, 1996), SPI= thickness (S1 & S2) x density divided by 1000. SPI calculations for the Early Permian Tasmanite Oil Shale and *Tasmanites*- rich horizons have been estimated as 2.5 bbl's m^2 (Bacon et al 2000, p. 48), and 3.78 bbl's m^2 (Reid 2003). The remainder of the Early Permian Woody Island - Quamby Formation (excluding the Tasmanite) has an SPI of 7 bbl's m^2 (Bacon et al. 2000. p48) and 6 bbl's m^2 (Reid, 2003). The Liffey Group has a calculated SPI of 1.1366 bbl's m^2 (Reid, 2003).

Author	Method	Petroleum System	Estimated Recoverable
Bacon, 2000. p48.	SPI	Gondwanan (including tasmanite)	9.5 bbl/m^2 or (2.97 MMM bbl's)
Burrett, 2004.	SPI	Gondwanan	2.6 MMM bbl's
Collings, 2008 [1].	ZETAWARE	Gondwanan & Larapintine	346.4 MM bbl's (oil) or 6 T scf (gas)
Collings, 2008 [2].	Monte Carlo	Gondwanan & Larapintine	594 MM bbl's (P90) (total of 17 drill-sites)
Guise, 2007.	Monte Carlo	Larapintine (Bellevue #1 site only)	118.5 MM bbl's or 219 MMM cf (gas)
Reid, 2003.	SPI	Gondwanan (including tasmanite)	9.78 bbl/m^2 or (3.01 MMM bbl's)

Table 1. Petroleum Estimates, Summary Table.

Method

Taking the variables such as source type, maturity, trap geometry, seal and reservoir characteristics into consideration, we have based our resource estimates on extensive geological data and a statistical technique based on the oil industry preferred Monte Carlo method. Guise (2007) used a similar version of the Monte Carlo statistical technique to calculate the petroleum potential of two structures in the Tasmania Basin.

The two petroleum systems present onshore Tasmania are: The Permian-Triassic, Gondwanan system (the Tasmania Basin) (figures 1 and 2), and the Ordovician-Devonian, Larapintine 2 petroleum system (figure 3). Each system is potentially prospective for oil and gas and has similar features and age respectively to the producing Cooper Basin in South Australia, and the Tarim Basin in China. In contrast; The Tasmania Basin Gondwanan source rock is much more prospective for oil, as it contains bands of type 1 kerogen containing the alga *Tasmanites* oil shale, which is commonly up to a metre thick. 1,127,948 litres of oil were produced by distillation of the oil shale between 1910 and 1932 (James, 1950. p21). The Larapintine 2 system also has a marine algal source and fresh samples in outcrop have a strong petroliferous odour (Chester, 2006). When age and maturity factors are considered, the Larapintine source rocks are interpreted to have the potential for generating wet and dry gas. See **tables 2-5** for source rock and reservoir statistics used in calculations.

If commercial quantities of oil and gas were to be discovered in The Tasmania Basin, four essential components must be present in the geology:

- Mature source rocks containing sufficient organic matter, which has been subjected to sufficient heat, time and pressure to generate large quantities of oil or gas. In order to preserve the resource, the original source must not be destroyed by either over-temperature or over-pressure conditions.
- A reservoir horizon or rock unit that has the potential to store the migrated hydrocarbons. The reservoir rock must have sufficient porosity and permeability to allow the storage of fluids, and then allow the economic removal and flow of fluids to the surface once discovered.
- An effective/impermeable sealing horizon that traps the hydrocarbons within the reservoir, preventing further migration out of the reservoir or loss to the surface (seep).
- A suitable structure over the reservoir and seal that concentrates the hydrocarbons in economic quantities. There are many types of stratigraphic traps described in oil producing provinces, and structures can take the form of an anticline, dome, or well-sealed fault blocks.
- The trap should be present before migration to prevent hydrocarbons seeping to the surface.

The method for estimating undiscovered resources from individual variables within the basin 'plays', is calculated by analysing the existing/available data. Once this information is calculated, the result is then multiplied by the other variables, leading to the calculation of the Total Potential Recoverable amount (P_t).

Using this method as a guide, the oil potential of The Tasmania Basin has been calculated using the following Monte Carlo formula parameters:

Where:
P_t is the Undiscovered Prospective Resource Estimate.
A_p is the Prospective Area of the basin.
G is the geometry correction.
h is the Gross reservoir thickness.
ff is the Trap fill factor, or Nett/Gross.
Por is the Porosity (fraction, expressed as percentage).
S_h is the Hydrocarbon saturation (water saturation %).
FVF is the Formation Volume Factor.
RF is the Recovery Factor.

Note: None of the above parameters are certainties, but can be estimated from easily available data within broad limits (see Morton, 1996b).

The Monte Carlo simulation is the most commonly used method for combining and expressing the uncertainties of the individual plays. By generating a frequency distribution curve for each parameter, then converting the result to a probability distribution, a random number between 0 and 1 is generated (0-100% probability). Combining the results of the probability distribution for each play into the formula gives an estimate of the petroleum potential of a specific site, or for the whole basin (see XCEL generated attachments). As each equation is computationally intensive; each play within the Tasmania Basin will be discussed individually and then combined to give a total oil potential (P_t).

Discussion of Plays:

The Tasmania Basin has many sites which contain all four of the essential components necessary for the accumulation of economic quantities of oil. So far, over 20 leads and prospects (well locations) have been identified onshore Tasmania

Prospective Area (A_p).
This is the area of the basin which is believed to contain all of the essential elements of a hydrocarbon play (and is also economically drillable). Seismic interpretation has been combined with local/regional mapping of the geology to high accuracy, including play and site specific thickness and lithology interpretation down to basement level. Using these constraints as a guide, a conservative 10% of basin area has been used for this calculation (see figures 1-3).

Geometry Correction (G).
This is the shape correction used for the potential reservoir, expressed as a percentage. For example: a triangular distribution (1/2 base x height = 50%), or 40/60/80% for other shapes which are used to calculate the reservoir geometry.

Gross Reservoir Thickness (h).
This measurement is the maximum vertical closure of the reservoir measured in metres (m). The thickness has been calculated from either measured (known outcrop thickness), or by calculating the two-way seismic profile at specific sites.

Trap Fill Factor (ff), or **Nett/Gross**.
As reservoirs in commercial basins can range in fill from 0% (dry well), to full at 100%. It is assumed that rich source rocks will lead to 100% fill.

Porosity (Por).
Average porosity for each reservoir is based on the available, independently verified studies of the measured in-situ reservoir rock characteristics of Tasmania.

Hydrocarbon Saturation (water content) (S_h).
The amount of oil within a reservoir depends on the porosity, but often not all of the reservoir contains oil and can contain large amounts of water. The Australian oil industry range of 30-70% water saturation is assumed for this calculation.

Formation Volume Factor (FVF)
As oil is brought to the surface, the drop in pressure changes the volume and causes the loss of volatiles (lighter fractions). For this calculation, an oil industry typical calculation of 76.9-90.9% has been used to compensate for the volume loss.

Recovery Factor (RF)
This factor converts petroleum in-place estimates to recoverable oil, and is mostly dependant on the mobility of the underlying aquifer and height of the oil column. Recovery Factor is based on production averages in the Cooper Basin (SA). Up to 75% of resource is assumed to be unrecoverable, unless expensive/complex recovery methods are employed (10-40% used).

Potential Plays: **1. Permian-Triassic (Gondwanan Petroleum System).**

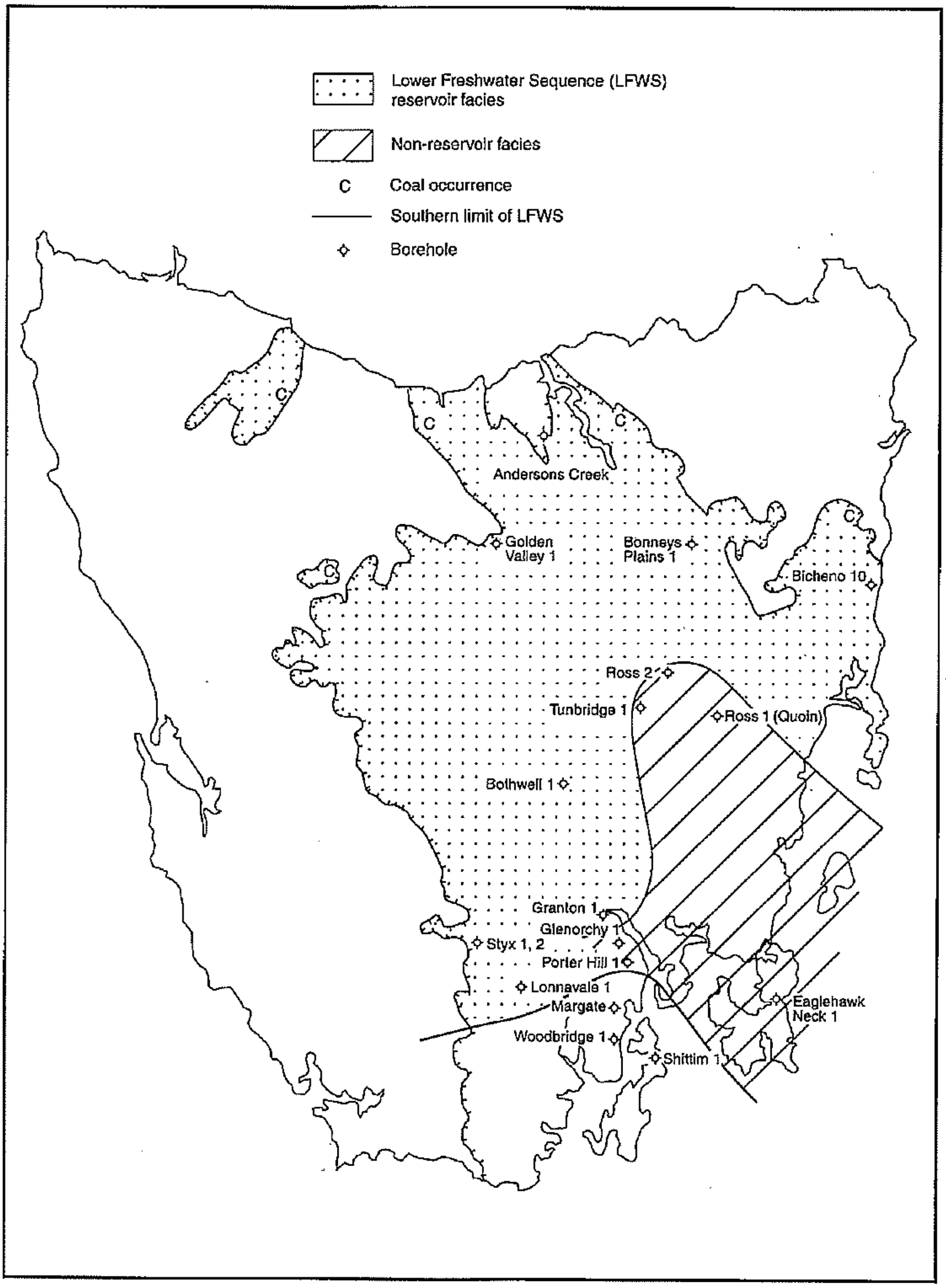

Figure1. Mapped extent of Permian, Lower Freshwater Sequence.
Coverage Area ~ 30,000km^2.
(Source: Bacon, 2000. p35).

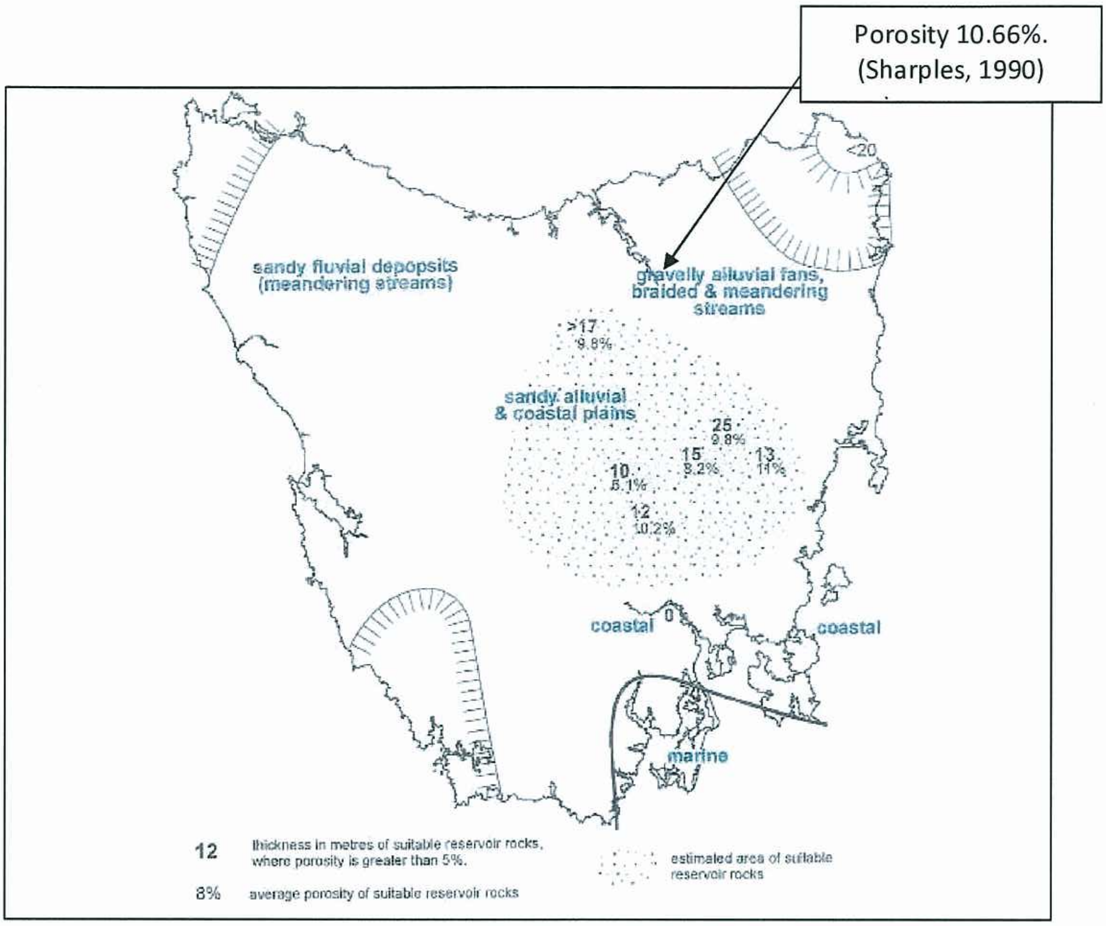

Figure 2. Mid-Permian freshwater sandstone reservoir area/thickness distribution (Liffey Group).
(source: Reid, 2003. p44).

2. Ordovician-Devonian (Larapintine 2 Petroleum System).

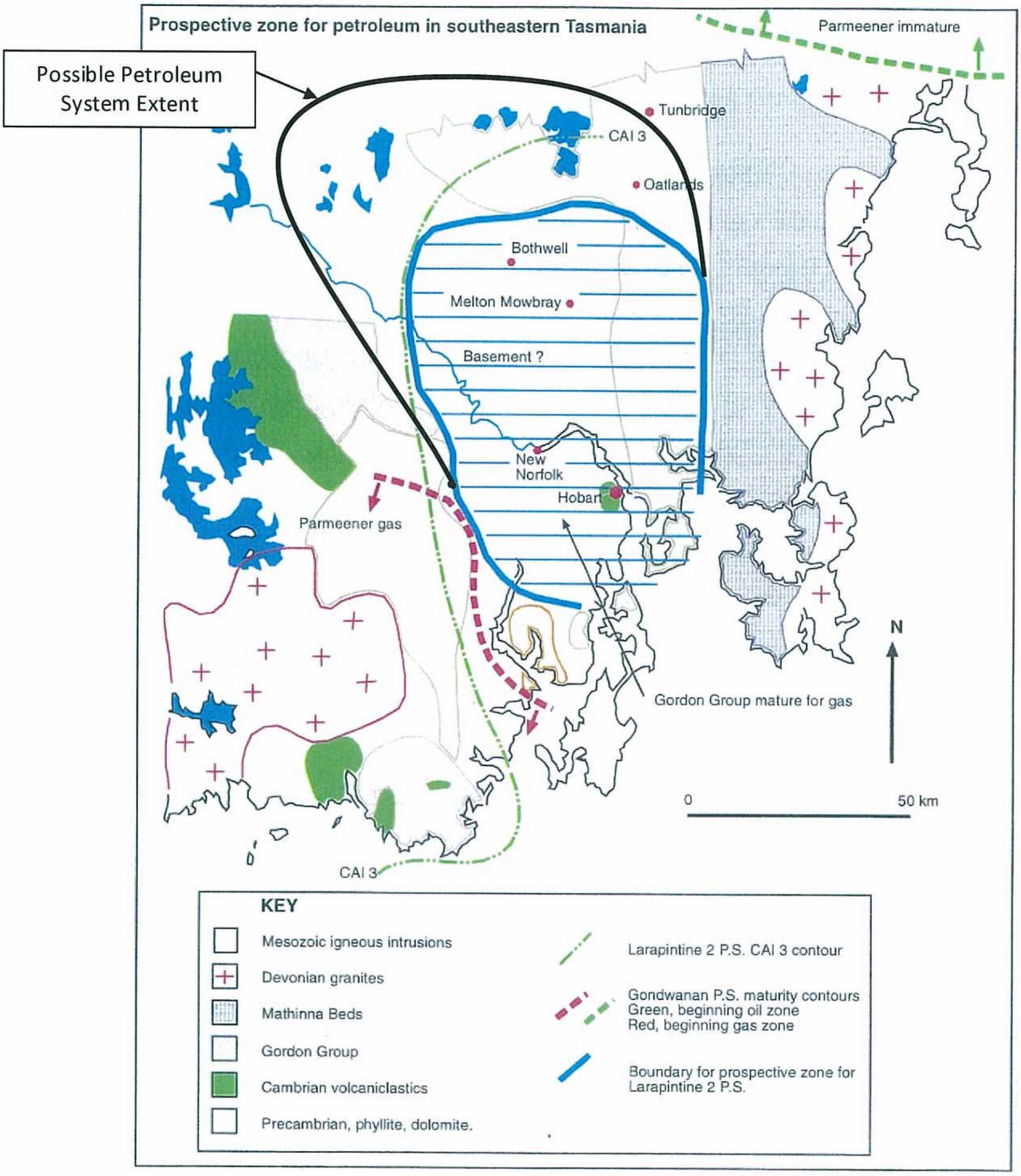

Figure 3. Most likely basin area, for Larapintine 2 Petroleum System.
Coverage Area ~ 11,500km^2.
(source: Chester, 2006. p136).

Gondwanan Petroleum System

Table 2. Mid-Permian - Mersey/Liffey/Faulkner Group.

Reservoir: Terrestrial sandstone (see Figure 1and 2). **Seal:** Mudstone and dolerite. **Source:** Either: Tasmanite oil shale, Woody Island Fm, Macrae Mudstone, Liffey Group (coal/torbanite). Or: singularly or a combination of these.

Summary of Monte Carlo parameters used.

Variable	Minimum	Likely	Maximum
Prospective Area of Basin #	1,000 km^2	1,500 km^2	2,500 km^2
Geometry Correction	0.4	0.6	0.8
Average Reservoir Thickness *	6m	25m	50m
Trap Fill Factor (Nett/Gross)	1%	50%	100%
Reservoir Porosity *	4.1%	9.6%	27%
Hydrocarbon Saturation (water)	30%	50%	70%
Formation Volume Factor	76.9%	83.3%	90.9%
Recovery Factor	10%	25%	40%

Source: #Reid, 2003. *Maynard, 1996.

Table3. Triassic - Sandstone (primarily unit 2).

Reservoir: Terrestrial sandstone. **Seal:** Mudstone and dolerite.
Source: Either: Tasmanite oil shale, Woody Island Fm, Macrae Mudstone, Liffey Group (coal/torbanite) or Upper Permian carbonaceous shales and Cygnet Coal Measures (unit 1). Or: singularly or a combination of these.

Summary of Monte Carlo parameters.

Variable	Minimum	Likely	Maximum
Prospective Area of Basin #	1,000 km^2	1,500 km^2	2,500 km^2
Geometry Correction	0.4	0.6	0.8
Average Reservoir Thickness #	10m	50m	120m
Trap Fill Factor (Nett/Gross)	1%	50%	100%
Reservoir Porosity *	5%	10%	20%
Hydrocarbon Saturation (water)	30%	50%	70%
Formation Volume Factor	76.9%	83.3%	90.9%
Recovery Factor	5%	10%	20%

Source: #Reid, 2003. *Bedi, 2003 and Sharples, 1990.

Larapintine 2 Petroleum System

Table 4. Silurian-Devonian - High Porosity Estimate.

Reservoir: Limestone (possible paleokarst), sandstone (see Figure 2). **Seal:** Mudstone/siltstone. **Source:** Upper Limestone Member of the Benjamin Limestone (marine carbonates) ^.

Summary of Monte Carlo parameters.

Variable	Minimum	Likely	Maximum
Prospective Area of Basin #	250 km^2	558 km^2	1,150 km^2
Geometry Correction	0.4	0.6	0.8
Average Reservoir Thickness *	50m	100m	200m
Trap Fill Factor (Nett/Gross)	1%	50%	100%
Reservoir Porosity *^	1%	5%	12%
Hydrocarbon Saturation (water)	30%	50%	70%
Formation Volume Factor	76.9%	83.3%	90.9%
Recovery Factor	10%	25%	40%

Source: #Burrett, 1996. *Maynard, 1996. ^Chester, 2006.

Table 5. Silurian-Devonian - Low Porosity Estimate.

Reservoir: Limestone (possible paleokarst), sandstone (see Figure 2). **Seal:** Mudstone/siltstone. **Source:** Upper Limestone Member of the Benjamin Limestone (marine carbonates) ^.

Summary of Monte Carlo parameters.

Variable	Minimum	Likely	Maximum
Prospective Area of Basin #	250 km^2	558 km^2	1,150 km^2
Geometry Correction	0.4	0.6	0.8
Average Reservoir Thickness *	50m	100m	200m
Trap Fill Factor (Nett/Gross)	1%	50%	100%
Reservoir Porosity *^	1%	3%	5%
Hydrocarbon Saturation (water)	30%	50%	70%
Formation Volume Factor	76.9%	83.3%	90.9%
Recovery Factor	10%	25%	40%

Source: #Burrett, 1996. *Maynard, 1996. ^Chester, 2006.

Discussion of Results

By applying the statistical Monte Carlo method to the measured variables associated with the Tasmania Basin, a range of possible petroleum generation scenarios were found. When all of the measured variables (such as basin area, porosity, trap fill factor ect) were taken into consideration for the modelling parameters: it became apparent that although the reservoir rocks have the necessary storage qualities, it could only be assumed that a small area of the basin would have the necessary trap and sealing structures to contain any generated hydrocarbons. For example: if we choose the total basin area without adjusting for structures, then a high probability for possible petroleum generation (P90) was found to be in the order of 8.1 MMM bbl's, which is 2 to 3 times greater than any amount calculated in previous studies and therefore this figure would be considered unlikely (see table 1).

A more realistic method for modelling the Tasmania Basin was therefore chosen, which assumed that only discrete locations in the basin, or approximately 10% of the available reservoirs would be capable of having the structure qualities to trap hydrocarbons. By choosing a conservative figure of 10% of the total reservoir area, the results obtained were not only found to be similar to previous study estimates, but also generated a more realistic P90 value of 786 MM bbl's (see attached Monte Carlo tables).

Conclusion of Play Analysis

This report has used the quantitative Monte Carlo method as the industry accepted tool for assessing the undiscovered petroleum potential of the Tasmania Basin (Morton, 1996b). The adapted Monte Carlo method has highlighted the undiscovered potential of the Tasmania Basin, where a conservative estimate (P90 low/conservative) indicates the prospective resource (P_t) could be 786 MM bbl's (or BOE) (Gondwanan+Larapintine 2). The attached XCEL table/graph of each play shows the calculations in detail, and provides a graphical representation of how the prospective resource estimate figures were attained.

While the estimates obtained are encouraging, the oil and gas potential of The Tasmania Basin highlighted in this report will require further geological investigation. Also note that all Potential (undiscovered) resource estimates should not be compared to traditional Proved, Probable and Possible reserves of known discoveries. With this in mind; the undiscovered estimates have been calculated to provide a quantitative indication or estimate of the basin potential, and therefore the basin will still require significant and continued exploration to establish the existence of commercial quantities of oil or gas.

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