NEW STUDY SUGGESTS REMOTE QLD-NT BORDER AREA HAS SIGNIFICANT OIL-GAS POTENTIAL

A new petroleum study has found that a massive area of outback Queensland and the Northern Territory could potentially play host to some of the country’s largest untapped reserves of oil and gas.

The findings are presented in a detailed technical paper titled “Prospectivity of the Southern Georgina Basin” released today by Perth-based Central Petroleum Limited (ASX: “CTP”).

Among the conclusions of the report are that the area within Central Petroleum’s four tenement applications in the southern part of the Basin – which equally straddles the Queensland-Northern Territory border but whose northern section extends well into the Territory – could host:

- Up to 650 million barrels of Undiscovered Oil Initially In Place (UOIIP), in addition to
- 50 trillion cubic feet of Undiscovered Gas Initially In Place (UGIIP).

Most of the prospective reservoirs the report says, are likely to be trapped in the region’s Middle Cambrian geological structures.

“It is very early days yet and the Basin’s known strata is a profound mix of geological profiles and petroleum indicators,” Central Petroleum’s Managing Director, Mr John Heugh, said today.

“However, the technical report released today centralised, then analysed and rebuilt the estimate modelling from all known data on this Basin built up over nearly two decades,” Mr Heugh said.

“Significantly, the Basin’s footprint in the southern area has been subjected to only limited exploration and not a single well has been drilled based on a compelling and exacting seismically defined closure.

“Most of the 23 wells drilled to date over the southern section, have reported numerous oil, bitumen and gas shows.”

“In particular, the Basin’s Arthur Creek Shale Formation is an extremely organic rich shale and regionally extensive.

“Its Total Organic Content (TOC) of up to 16% suggests it is a very rich oil source and compares more than favourably with the oil generative potential qualities of the Bakken Shale in the United States and Canada.”

The report says that up to 43 billion barrels of oil may have migrated through the 14,000 km2 of ATPs 909, 911 and 912 – Central Petroleum’s permit application areas in the Basin’s southern extension in far west Queensland.

“Based on a conservative assumption that up to 1.5% of this migrated oil may have been trapped in fractures, the area’s potential within our footprint could be as high as 650 MMbbls (UOIIP) in unconventional play types alone,” Mr Heugh said.

“There is not enough data as yet to postulate how much of this could be recoverable or not, and in particular, what drive mechanisms may be available to facilitate extraction.
“We do expect oil potential additional to non-conventional plays to lie within the southern Basin’s shallower and regionally extensive sandstones above the Arthur Creek Formation and where we know from equivalent sands drilled, many of these play types occur at less than 1,000m depth and exhibit porosities of more than 15% in channel sands.”

In the Basin’s deeper Toko Syncline, the report finds that the region’s widespread thermal cracking of oil pools and gas accumulation could have generated up to 69 trillion cubic feet of gas.

In the wake of today’s findings, Mr Heugh said Central Petroleum’s future exploration campaigns for the southern Georgina would now most likely focus on developing a cogent data base of modern seismic based around conventional and unconventional (gas or oil in fractured shale and other tight reservoirs) trap definition - to be followed by drilling.

“In pursuit of unconventional production in the southern Georgina, we can see upside in applying state-of-the-art horizontal drilling coupled with fracturing(*) techniques,” Mr Heugh said.

Central Petroleum’s permit application expansion into the southern Georgina Basin is a contributing factor to the Company’s position as the largest holder of prospective oil and gas acreage in onshore Australia. This portfolio includes the majority of the Pedrika and Amadeus Basins on the SA-NT border and all of the known Lander Trough in the NT.

The Company’s exploration targets include coal seam gas, oil, gas and helium.

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(*) Frac ing comprises the artificial induction of fractures via the application of hydraulic pressure from the well bore to facilitate production of oil and or gas.
Prospectivity of Unconventional Middle Cambrian Reservoirs in the southern Georgina Basin

(CTP Technical Note 010509)

Greg Ambrose Manager-Geology
John Heugh Managing Director
Central Petroleum Limited

- Up to 650 MMbbls of UOIIP (Undiscovered Oil Initially-In-Place-SPE\(^1\) and up to 50 TCFG of UGIIP (Undiscovered Gas Initially-In-Place-SPE) could occur in Central’s permits in the southern Georgina Basin.\(^2\)

- The Southern Georgina Basin, straddling the border between the Northern Territory and Queensland, has had limited exploration and to date, not a single well has been drilled based on a cogent seismically defined closure, but numerous oil, bitumen and gas shows have been reported from most of the widespread 23 wells drilled to date.

- The Arthur Creek Formation in the Southern Georgina Basin includes black laminated microbial organic rich shales which are regionally extensive and represent very rich source rock lithologies with Total Organic Content (TOC) up to 16% comparing favourably with the oil generative potential qualities of the Bakken Shale in the USA and Canada.

- Well credentialed studies by a team from the USSR Academy of Sciences completed in 1991 and 1992 on behalf of Pacific Oil and Gas estimated that 40 billion tonnes (320 billion barrels -320 Bn.bbls) of oil has been generated and has migrated from Middle Cambrian source rocks (predominantly the Arthur Creek Formation) in the southern Georgina Basin.

- Oil expulsion began during early Ordovician sediment loading and continued through the late Ordovician Rodingan Movement before culminating during the Devonian-Carboniferous Alice Springs Orogeny (ASO).

- Some oil accumulations were destroyed in part and oil remigrated to some extent during the ASO. On the Bradley Shelf, preserved oil pools could occur in earlier formed structural-stratigraphic plays providing undisturbed reservoirs where isolated from hydrothermal fluid flow and other geothermal effects.

- Within Central Petroleum Limited’s (Central) permit application areas on the Bradley Shelf (ATPs 909, 911 and 912) totalling some 14,000 km\(^2\), up to 43 Bn.bbls of oil may have been generated and become mobile within Lower Arthur Creek Formation shales. A proportion of this could occur in unconventional fractured shale plays in this unit analogous to an extent with the Baxter/Bakken Shale plays in the USA/Canada. There is additional potential in Central’s EPA 132 not described here.
Based on the reasonably conservative assumption that up to 1.5% of this migrated oil may have been trapped in fractures within the Arthur Creek Shale, the potential of the Arthur Creek Shale in Central’s permit application areas could be as high as 650 MMbbls (UOIIP). There is not enough data as yet to postulate how much of this could be recoverable or not and in particular what drive mechanisms may be available to facilitate extraction. Locally, in shallow areas, oil and or gas generative pressure may have fractured host rocks and sufficient pressure retained to enable unstimulated production, whilst deeper areas may be capable of unstimulated production via normal hydrostatic pressure increase with depth.

Additional oil and or gas may have been trapped in conventional play types including regionally extensive channel sands, deltaic fans and tempestites of the Steamboat Sandstone lying conformably above the Arthur Creek Formation. Many of these play types occur at less than 1,000m depth and where the equivalent sands have been drilled, porosities over 15% have been reported.

One such Steamboat Sandstone play type (occurring in the NT outside of Central’s acreage) is partially defined by old vintage seismic and based on reasonable assumptions could have UOIIP potential of 230 MMbbls. There are many similar plays available for follow up exploration in Central’s permits.

In the deeper Toko Syncline, increased sediment loading and relatively high geothermal gradients during the ASO resulted in thermal cracking of oil pools and gas accumulation was widespread.

In the Toko Syncline up to 69 TCF could have been generated. Viable unconventional reservoirs could include fractured/vuggy silty dolomites of the Upper Arthur Creek Formation (UGIIP= 50 TCF) and fractured silty shales of the Lower Arthur Creek Formation (UGIIP= 6.1 TCF).

Future exploration efforts in the region should be directed at developing a cogent data base of modern seismic focussed on conventional and unconventional (gas or oil in fractured shale and other tight reservoirs) trap definition to be followed by drilling. In pursuit of unconventional production, potential emphasis should be placed on state of the art horizontal drilling coupled with fracccing techniques. ("Fraccing"- artificial induction of fractures via the application of hydraulic pressure from the well bore to facilitate production of oil and or gas)

Notes:

1 SPE: Society of Petroleum Engineers preferred format for hydrocarbon accumulation volumetric descriptions

2 This report was compiled by Central Petroleum Limited and does not necessarily reflect the views of Petroleum Exploration Australia, (PXA), conditionally a Joint Venture partner in the areas described
Petroleum Geology

The key elements of Central Petroleum’s Queensland application areas in the southeastern Georgina Basin are the Toko Syncline and a northern shelf area, namely the Bradley Shelf; the permits cover an area of 14,367 km² (Figs 1, 2 and 3). Most of the following discussion relevant to this region comes from Ambrose et al (2001), Draper (2007), and Ambrose and Putnam (2007).

The basin has two well documented Middle Cambrian source rocks (Lower Arthur Creek Formation and Thorntonia Limestone – Table-1) which are believed to have expelled up to 40 billion tonnes (320 BBbls) of liquid hydrocarbons based on detailed evaluation of the southern Georgina Basin by a Russian study group (SIBGEO, 1991 and 1992). Two target areas are discussed, the Toko Syncline and the associated Bradley Shelf on its NE margin (Fig.3).

Most of the 23 wells drilled to date in the southern Georgina Basin record hydrocarbon shows even though none is certain to have intersected a valid trap except Ethabuka-1 in the Toko Syncline. It is well recognised that vast amounts of oil migrated from Middle Cambrian source rocks beginning in the early Ordovician. Oil entrapment was widespread, but there was major remigration and thermal cracking of oil in the Toko Syncline during the Alice Springs Orogeny (ASO); some oil pools were probably destroyed at this time. For example, Central has recently identified a fossil oil column at the Ordovician Coolibah/Nora shale reservoir-seal couplet in Ethabuka-1 (Fig.5). The Coolibah fossil oil zone is now largely occluded with bitumen (including pyrobitumen) forming effective seal to an underlying sandstone in the Kelly Creek Formation which flowed gas at 200 mcfd. Note that the pyrobitumen is interpreted as the residue of cracked light oil migrated from Middle Cambrian source rocks lower in the section. No water leg has been established in the well.

The Toko Syncline is asymmetric, wedge-shaped and lies between the Toomba Fault and the northward trending Bedourie Block. It was a major depocentre from the Neoproterozoic (tensional rifting) through to Devonian/Carboniferous foreland basin development during the Alice Springs Orogeny. The loading event which facilitated initial oil generation from the Middle Cambrian section (Lower Arthur Creek Formation/ Thorntonia Limestone) in this depocentre probably occurred in the Early Ordovician (sediment load in the axis of the syncline probably exceeded 2000m). Palaeothermal gradients were probably relatively high given proximity to the Arunta Block. Additional sediment loading with associated elevated thermal gradients occurred later during several phases of the ASO, the earliest being the Late Ordovician Rodingan Movement. At this time synorogenic deposition of the Ethabuka Sandstone occurred over a wide area of the Toko Syncline reaching a thickness of up to 1100 m and this, together with additional loading during the Early-Middle Devonian phase of the ASO (Cravens Peak Beds), resulted in thermal cracking of earlier formed oil deposits eg. in Ethabuka-1. Remigration of oil from existing oil pools probably occurred on the Bradley Shelf during the ASO but deformation was relatively mild and some entrapped oil is believed to have been preserved, especially in unfaulted stratigraphic traps (Fig.6).
Figure 1. The Georgina Basin

Figure 2. Central's interests including the Southern Georgina Basin
Figure 3. Arthur Creek Isopach and Maturation Zones, SE Georgina Basin.

1. Hagen Member  
2. Eurowie Sandstone  
3. Hagen Member

Oil shows in the southern Georgina Basin, not in Central’s acreage but thought to be representative of the basin generally. (courtesy NTGS)
Arrinthrunga Formation (2285m)
(Platformal)
Aquifer Salinity 10 - 15000 ppm

Steamboat Sandstone (2457m)
(Near Shoreline)
Arthur Creek Formation (Upper) (2503m)
(Inner Ramp - Middle Ramp)

Formation Testing
1) 6 valid DST's / straddle tests run over the gross interval 2587m - 3318m.
   (Upper - Lower Arthur Creek Formation and Thorntonia Limestone).

2) All zones indicated “Tight Reservoir”.

3) No formation water or hydrocarbons were recovered.

NB. Hydrostatic several hundred PSI overbalanced to formation pressure.

Arthur Creek Formation (Lower) (2952m)
(Outer Ramp - Basinal)

Gas shows ≤100 units
Ethane ≤1%
Fracture development as on dipmeter and in Core 2
NB: 1 Unit = 200ppm

“Hot Shale” (3210m)
Thorntonia Limestone (3245m)
Granite Basement (3265m)

Figure 4. Mirrca-1 Well Log Section – SE Georgina Basin
Figure 5 Lithology Ethabuka-1

ETHABUKA 1 WELL SECTION

Interpreted

? fossil oil column

5580 - 5880m fluorescence and cut with bitumen in fractures.
Some pyrobitumen.
5880m pyrobitumen.

GTS at 5883m
Q ~ 200mcfd. against full hydrostatic head.

Note:
5690 - 5840m
Sandstone cuttings are subordinate.
Gas bubbles exuding from sandstone cuttings.
Gas derived from porous streaks in the sandstone.

No Elogs Available

Oil Show
Bitumen and Pyrobitumen

Nora Formation
Coolibah Formation
Kelly Creek Formation

Author: G.Ambrose  Drawn: Central Petroleum  Date: 15th April 2009
Hydrocarbon Potential in Unconventional Reservoirs

Central’s exploration strategy in its southern Georgina Basin permits has in part targeted early formed combination structural-stratigraphic plays which are more likely to include relatively high quality conventional reservoirs in undisturbed, secure traps providing reservoir niches isolated from hydrothermal fluid flow and other thermal effects related to the ASO. Many of the conventional plays relate to the facies architecture of the Middle Cambrian basin as described in Figure 6a. Some of these structural-stratigraphic plays are described in detail in Ambrose and Putnam (2007) and are important targets on the Bradley Shelf; an example of a valley infill play (channel sand) occurs in Fig. 6b. In addition, unconventional reservoirs dependent on fracture development are important gas and oil targets in the Toko Syncline and on the Bradley Shelf respectively.

![Figure 6a Southern Georgina Basin Facies Model](image)

**Figure 6a Southern Georgina Basin Facies Model**

It should be emphasized that in this basin that widespread hydrocarbon shows (bitumen, live fluorescence and gas shows) indicate a vast amount of migrated oil may not have accessed a migration pathway leading to a valid structural or structural/stratigraphic trap. Indeed a proportion of the hydrocarbons may be entrapped outside of structural closure within source rock shales and in brittle, fractured dolomitic sediments which are common in the Arthur Creek Formation and Thorntonia Limestone. The potential for unconventional reservoirs at these stratigraphic levels has been largely ignored in the past but a description of these play types and estimates of undiscovered hydrocarbons-in-place are documented in this report.

In the area of the gas preservation zone (early formed oil cracked to gas) in the Toko Syncline, up to 69 TCF gross undiscovered gas initially in place (UGIIP) could have been generated from Middle Cambrian source rocks. Viable reservoirs could occur in fractured lower Arthur Creek shales (6.1 Tcf) or, more likely in brittle fractured/vuggy...
silty dolomites of the upper Arthur Creek Formation (40.6 Tcf). The total volume of migrated oil in the area of the oil preservation zone on the Bradley Shelf, some of which could be held in fractured shales/dolomitic sediments or unaffected structural/stratigraphic plays which have retained trap integrity, is of the order of 43 BBbl.

Figure 6b Example of a Transgressive fill (channel) sand in the Steamboat Sandstone outside of Central’s acreage.

Photos of core from the Arthur Creek Formation, dark grey black to the right-high TOC content up to 16%. Not in Central’s acreage but thought to be representative of the Basin generally. (courtesy NTGS).
Vuggy dolomite, upper Arthur Creek Formation-outside of Central's acreage but thought to be representative of the Basin generally. (courtesy NTGS).
**Toko Syncline - Unconventional Gas Reservoir Plays**

Within Centrals acreage, gas targets are restricted to the Central Toko Syncline and this area, together with the limit of the oil preservation window, are shown in Figure 3. The three key wells within the syncline are The Brothers-1, Mirrca-1 and Ethabuka-1; the the latter two wells are shown in Figures 4 and 5.

Available maturity data from the aforementioned wells suggests that all of the petroleum liquids originally generated and trapped in the Toko Syncline have been cracked to gas. This is significant because it is under these conditions of changing fluid volume and pressure, that the capillary pressure of a water wet pore system may be exceeded and gas can replace free water in the pore space of thin interbedded clastic reservoirs (Law, 2002). In some instances gas saturated reservoirs can expand below a structural spill point forming unconventional basin centred gas accumulations. The most likely candidate for unconventional gas reservoirs are fractured dolomitic sediments in the upper Arthur Creek Formation which recorded significant gas shows in Mirrca-1.

Ethabuka-1 flowed dry gas at 200 mcf/d from the Coolibah Formation without recovering formation water. The thickness of the gas column and the extent to which the gas column could extend downdip of the well on this large structure, remains unassessed as does the potential of unconventional reservoirs in the Arthur Creek Formation. No Elogs were run over the gas bearing zone but a litholog is shown in Figure 4. Due to the geothermal regime it is not expected that any oil deposits would remain intact in this terrane.

The most significant data in the gas preservation zone comes from Mirrca-1. Key information from the well is summarised below with additional data shown in Figure 4.

**Mirrca-1:** There has been little systematic study of fracture systems developed in the Arthur Creek Formation in this well or in the well completion report but some information is available from a review of fracture systems using elogs; the results are summarised below and shown in Figure 4:

- Fractures in the Palaeozoic section above the Arthur Creek Formation are rare but were observed over the gross interval 2520 m to 2650 m in the latter. Fractures and vugs (some open) were recorded in Core 2 in the mid Arthur Creek Formation. Strong gas shows up to 100 units (C2= 50 units) were recorded whilst corening fractured zones and large vugs which exuded a strong gas odour.
- All interpreted fracture zones are shown in Figure 4.
- A total of 9 DST’s were run over various zones within the Arthur Creek Formation but all tests were either misruns or tight tests; there were no recoveries from the Arthur Creek Formation of either formation water or hydrocarbons. It is significant that there was overbalance of several hundred psi between the hydrostatic head and probable formation pressure (noted in the Well Completion Report) which may have damaged potential fracture networks and inhibited gas shows.
Conclusion: The complete absence of water below the Top Arthur Creek Formation, which yielded significant gas shows, begs the question of potential gas flows if underbalanced drilling, horizontal fraccs and state of the art completions were applied in future drilling programs.

Bradley Shelf Unconventional Oil Plays

The Bradley Shelf, which lies mainly in the oil preservation zone, is outlined in Figure 3, and comprises a broad relatively shallow /undulating basement terrane hosting a condensed Georgina Basin sequence which shelves gently northwards towards the Bedourie Basement complex. Key wells include Bradley-1, Owen -2, Todd-1, Netting Fence-1, GSQ Mt Whelan-1 and Lucey Creek-1 (Fig.3). A reference well for the area is Todd-1 which lies in the oil window to the NE of the Toko Syncline.

The Arthur Creek Formation shales are widespread on the Bradley Shelf and are believed to lie mainly in the oil window. The carbonaceous, dolomitic shales and siltstones provide a Type 1 oil prone source rock comprising algal/bacterial organic matter with TOC’s ranging up to 16%. One of the key current unknowns necessary for exploration success on the Bradley Shelf is the definition of areas relatively unaffected by the Alice Springs Orogeny. Thermogenic, tectonic and also hydrothermal influences are believed to have destroyed some oil fields at this time but seismic indicates large areas were relatively unaffected.

The Thorntonia Limestone also includes oil source and potential reservoir rocks and is also an oil target. However, this target is downgraded by the fact that hydrothermal fluids have permeated this reservoir over a wide area effectively cracking and destroying oil accumulations during the high heat flow phase of the Alice Springs Orogeny. This has occurred to a far smaller extent in the Arthur Creek Formation and the destructive impact of hydrothermal fluids is thought to be relatively low on the Bradley Shelf, being concentrated near basement “hot spots” (eg adjacent to the Arunta Block) and also along major transpressional faults originating at basement levels.

On the Bradley Shelf, a number of wells record significant oil shows at several stratigraphic levels. The red beds of the upper Chabelowe Formation provide regional seal and oil fluorescence occurs below this seal at the levels of the Arthur Creek Formation, Steamboat Sandstone and basal Arrinthrunga Formation. Arthur Creek Formation shales seal the Thorntonia Limestone. Previous studies have attributed the shows to oil accumulations destroyed during the Alice Springs Orogeny but given the very sparse seismic coverage and only mild folding in the basin, this seems very unlikely. Most hydrocarbon shows are believed to relate to migration pathways which are sometimes local (eg within the Arthur Creek Formation) but in some instances may relate to long distance migration and involve faulting and fracture systems.

NB: The following undiscovered oil-in-place and undiscovered gas-in-place calculations rely on sparse data and refer to undiscovered in-place numbers only. No estimates of recoverable reserves are made because in many cases recovery factors in the regional sense of continuous reservoirs are not available.
Toko Syncline: Total Gas Generated from Lower Arthur Creek Shales (Gas only preservation window)

Area = 615,000 acres  
Gross Column = 1000 ft  
Shale % = 0.50  
Geometric Factor = 0.95  
Density = 162.2 lbs/cu.ft  
One ac.ft = 43,560 cu.ft  
Scf/ton = 75 scf/ton  
UGIIP = 69.0 Tcf (Gross Gas Generated)

Assuming Average Gas Contents = 14 “low”, 75 “best”, 100 “high” scf/ton.

Notes: 1) Total Gas Generated in the Toko Syncline applies to total shale volume (assuming 50% shale). No attempt is made here to estimate recoverable reserves.

2) This estimate refers to the total gas generated from the shale ie as free gas in pores and fractures and as gas sorbed onto organic matter. The estimate does not account for that portion of the resource destroyed during tectonism associated with the Alice Springs Orogeny.

3) The “best” scf/ton value applied to this prospect is that assigned to the Ohio shale in North America, which is analogous to the Arthur Creek Formation in terms of organic content and thermal maturity.

Toko Syncline: Unconventional Reservoired GIP
Lower Arthur Creek Fm (Fractured Shale - Gas Preservation Window) in a continuous reservoir

Area = 615,000 acres  
Gross Column = 1000 ft  
Fractured Shale / Dolomitic Silt = 10% net/gross  
Fracture Porosity = 0.015  
Hydrocarbon Saturation = 80%  
Geometric Factor = 0.95  
Gas Expansion factor = 200  
One ac.ft = 43,560 cu.ft  
UGIIP = 6.1 Tcf
**Toko Syncline: Unconventional Reservoired GIP**

*Upper Arthur Creek Fm (Continuous Reservoir- Fractured Dolomitic Siltstone - Gas Preservation Window)*

- **Area** = 615,000 acres
- **Gross Column** = 2200 ft
- **Fractured/vuggy Dolomitic Silt** = 25% net/gross
- **Fracture Porosity** = 0.02
- **Hydrocarbon Saturation** = 80%
- **Geometric Factor** = 0.95
- **Gas Expansion factor** = 200
- **One ac.ft = 43,560 cu.ft**
- **UGIIP** = 50.6 Tcf (Total gas in fractures)

**Bradley Shelf: Total Migrated Liquid Hydrocarbons From the lower Member of the Arthur Creek Formation - in the oil preservation window**

- **Area** = 810,000 acres
- **Gross Column** = 1000 ft
- **Fractured/vuggy Dolomitic Silt** = 50% net/gross
- **Fracture Porosity** = 0.02
- **Hydrocarbon Saturation** = 80%
- **Geometric Factor** = 0.95
- **Migrated HC’s per Tonne** = 5 kg/tonne (one half SIBGEO estimate)
- **One ac.ft = 43,560 cu.ft, 7.1 Bbls/tonne**
- **Total Migrated Oil** = 6 Billion Tonnes
  = 43 BBbls Migrated Oil

**Nb:1)** This figure refers to total migrated oil and uses data from SIBGEO studies (1991 and 1992).

**References**

Greg Ambrose **Bibliography**


