# Hydrocarbon Pools Of The Southeastern Great Slave Plain, Northwest Territories

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## Introduction

The geology of hydrocarbon pool discoveries in the southeastern Great Slave Plain will be discussed. Geological particulars for each discovery well will be highlighted at Cameron Hills, Tathlina, Rabbit Lake, Kakisa and Grumbler. The discoveries examined here are grouped together because of their common geological features and their location in the geographical region south and southwest of Great Slave Lake.

*Exploration History*
On the Great Slave Plain, exploration began with the drilling of two wells on oil seeps near Great Slave Lake in the 1920s. These wells were not successful and exploration did not resume until 1946. In 1954, J.C. Sproule and Associates mapped surface structures near Rabbit Lake that indicated possible fault closure. Subsequent test hole drilling and the drilling of Briggs Rabbit Lake No. 1 and No. 3 confirmed the closure by testing gas from the Sulphur Point Formation. In 1959, Shell Canada Ltd. drilled four Alexandra test holes (near Tathlina Lake, see *Fig. 1*), all of which were abandoned. Several other companies also drilled wells in the Alexandra area without success.

The main phase of exploration was launched in the 1960s and 1970s coincident with the discovery of the Rainbow reefs in northwestern Alberta. Seismic was used to identify and map the extent of the Middle Devonian Presqu'ile Barrier reef. In 1965, Hudson's Bay Oil and Gas Company Ltd. obtained exploration permits in the Grumbler area. Shell drilled six wells into the Precambrian in 1969 to earn an interest in these lands. Of these wells, the Grumbler G-63 tested gas from the Slave Point Formation.

In 1973, Pacific Petroleum Ltd. and Amoco Petroleum Corporation followed up Shell's original efforts in Tathlina with a gas discovery in the Slave Point Formation at Tathlina N-18. Interest tapered off later because the proven reserves were not large enough to merit economic development at that time.

Renewed activity, beginning in the mid 1990s, primarily by Paramount Resources Ltd., has resulted in a number of wells being drilled in the Cameron Hills area. Paramount at this time holds several production licenses valid until 2017. A

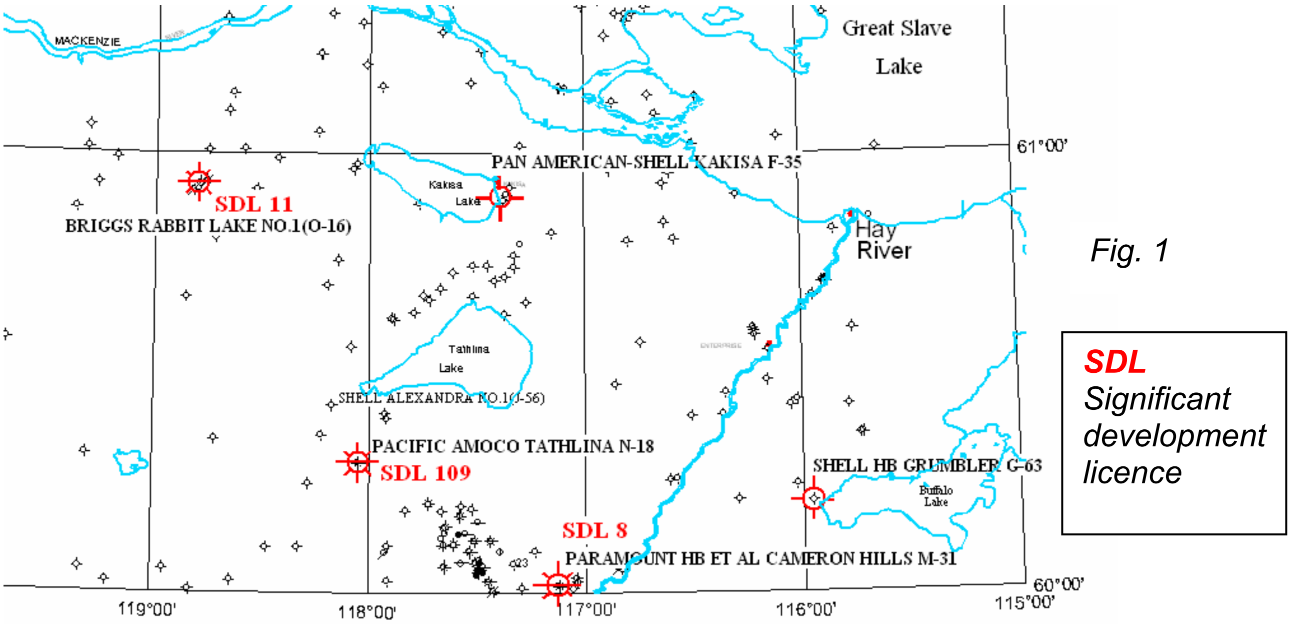



*Fig. 1*

*Southeastern Great Slave Plain: Pool Wells*

pipeline was constructed in the winter of 2001-02 to connect several gas wells into the gathering system in nearby Alberta. A small amount of oil production is currently being trucked to an oil battery in Alberta.

## Geology

*Structural Setting*

During the Precambrian, the Great Slave Plain was subjected to extensional tectonics with the opening of the proto-Pacific ocean along the edge of the North American craton. Horsts and grabens were developed in the basement rocks; these structures continued to influence structure and deposition throughout the Phanerozoic.

Sometime between the Precambrian and early Devonian an east-west trending upland - the Tathlina Arch - developed (*Fig. 2*). Cambrian clastic sediments are not found in the area, so the arch was likely emergent at that time. The higher parts of this feature localized the growth of the Presqu'ile Barrier during the middle Devonian; the Arch is closely coincident with the barrier edge. A series of northwest and northeast trending lineaments cut the arch. On the steeper flanks of the Tathlina arch isopachs of middle Devonian strata are thinner, or non-existent. The isopach for the middle Devonian interval between the Upper Chinchaga and Sulphur Point is considerably thinner, or absent, over the crest of the arch. Periodic re-activations of lineaments during the middle Devonian acted to vary isopachs along trend. By late Devonian, the influence of the Arch became less, as indicated by isopach maps that show a progressive thinning onto the craton to the east.

North of the Presqu'ile Barrier, during the middle Devonian, the primary facies was shale deposited in greater water depths. A number of patch reefs punctuate the shale basin. To the south of the barrier, carbonate and evaporitic shelf facies dominated in relatively shallow conditions. A widespread transgression followed in the late Devonian, accompanied by deeper water carbonates and shales.

The entire region was structurally relatively high in the late-Cretaceous causing the erosion, or non-deposition, of sediments deposited in the foreland basin of the emerging Cordillera to the west. Compared with British Columbia and Alberta, the western Mesozoic seaway subsided less during the Cretaceous and therefore preserved less sediment.

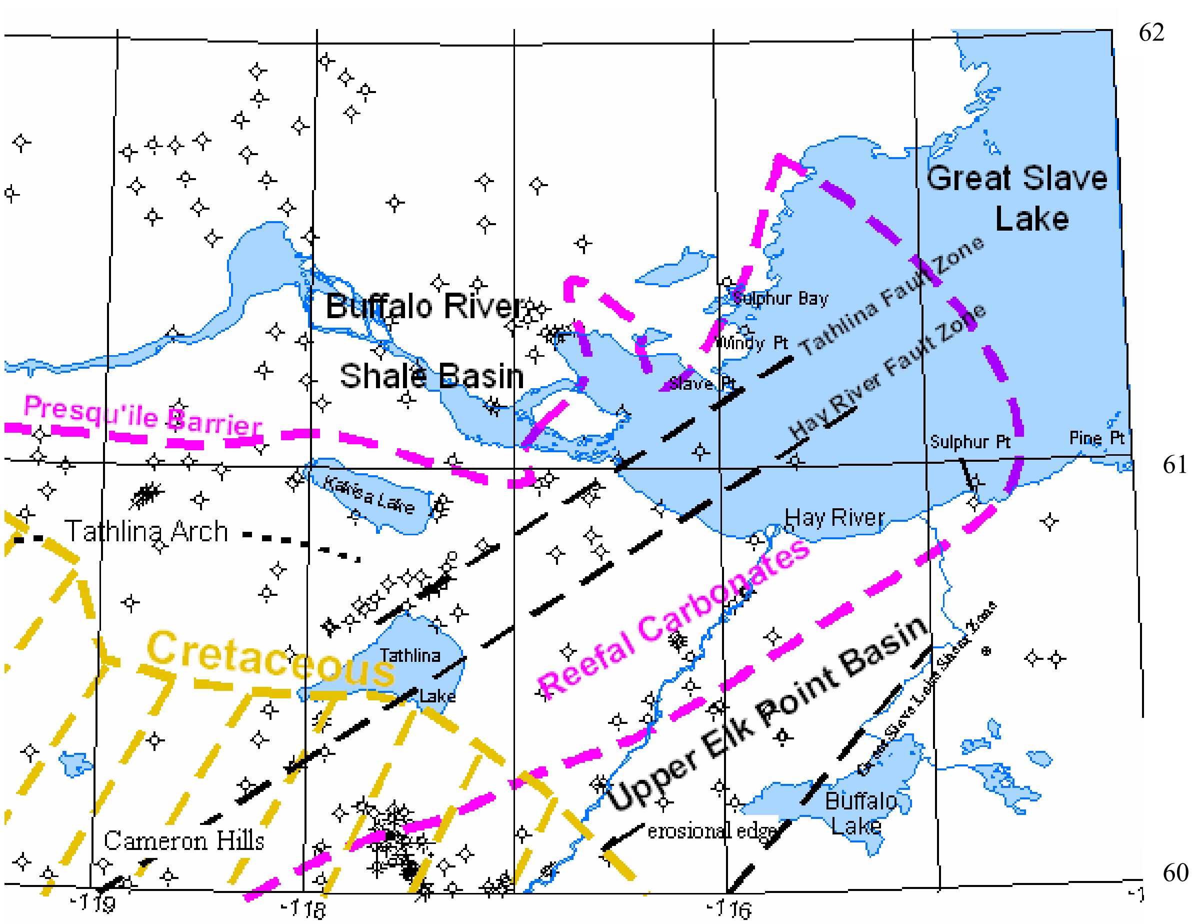
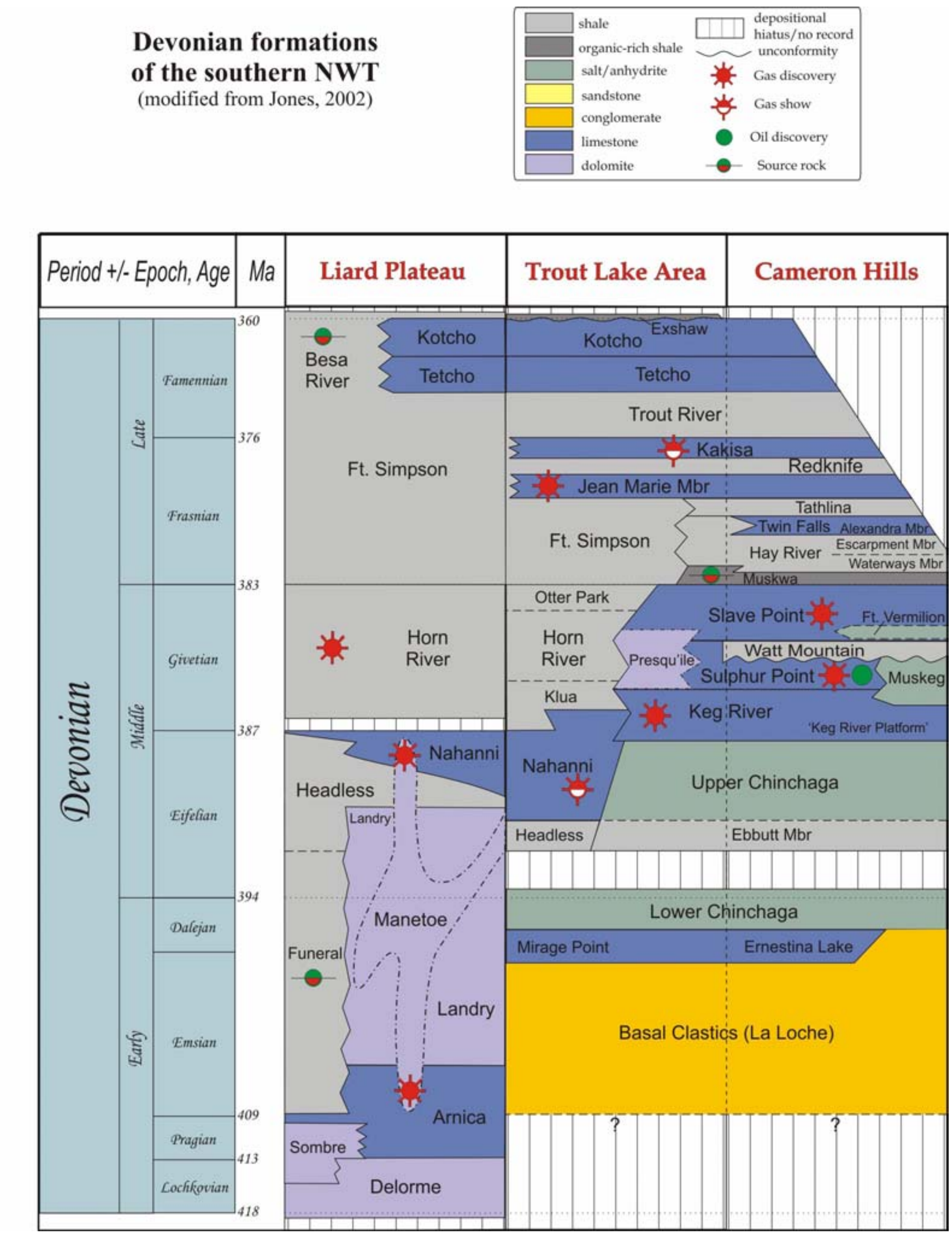



*Fig. 2*

Structural and sedimentary features, southeastern Great Slave Plain

*Stratigraphy*

Discoveries so far in the southeastern Great Slave Plain have been in middle Devonian carbonates. The presence of the Tathlina Arch caused lateral facies differences during the early and middle Devonian, especially during times of relatively low water level. Consequently, the stratigraphy and resulting stratigraphic nomenclature are complex. The table of formations presented below summarizes current thinking on the stratigraphy of that period.



## Pools

*Cameron M31*

Most seismic studies conducted so far have been based on the assumption that uplifted fault blocks promoted reef growth. Initial work suggested that an uplifted and bare Precambrian quartzitic surface would be suitable for reef growth. Where high velocity Keg River carbonates overlie high velocity Precambrian rocks there is only a very small change in acoustic impedance. On that basis, horst blocks were identified where the Precambrian seismic reflection is weak, and where the Slave Point to Precambrian isochron is thin.

The Slave Point gas reservoir at M31 is developed near the top of the formation, below 6 metres of tight limestone in a fossilferous zone. The porosity (average 7%) may be due to locally favourable facies development on the crest of a fault block, or to enhancement of porosity in proximity to a fault. Evidence for fracturing is found in the samples. Lateral trapping at M31 results from juxtaposition, through faulting, with shales of the Waterways member or denser limestones of the Slave Point. Reserves for this pool are estimated to be 1.9 Bcf.

The *Keg River reservoir* at M31 is developed in sucrosic dolomite that exhibits good porosity over the zone of interest. Streaks of porosity of 14-15% are observed both on the logs and in the samples; average porosity is close to 9%. Dense anhydritic dolomite forms a cap. Muskeg anhydrites or tight Keg River that have been brought into contact with the porous Keg River by block faulting creates the lateral trap. *Reserves for the Keg River are estimated at 3.0 Bcf.*

M31 is within Significant Development Licence 008.

*Tathlina N18*

Favourable facies conditions for a Slave Point reservoir resulted when it was draped over a pre-existing uplifted Precambrian fault block. Proximity to faulting may also have worked to enhance porosity by fracturing during re-activations or channelling of porosity enhancing fluids.

Seismic evidence shows that the reservoir is bounded on the northwest by a series of en echelon faults. It is capped by grey to black calcareous Muskwa Formation shale. The N18 location was selected on the up-thrown side of a fault that appears to have originated in the basement and continued through the Slave Point. What was originally thought to be structural rollover (block faulting was not observed in the field) was mapped, providing closure to the northeast. The porous Slave Point beds are sealed to the northwest by contact with Muskwa shales that have been relatively down-dropped into a graben structure.

The reservoir rock consists of dolomitic light brownish grey wackestones to packstones with traces of leached pinpoint vuggy porosity underlain by a thick section of tight limestone. Average porosity is 10% over a 9-metre pay zone.

*Estimated reserves are 4.6 Bcf.* N18 is within Significant Development Licence 109.

*Rabbit Lake No.1 (O16) and No.3 (B07)*
The Sulphur Point Formation at these locations is a highly porous, fragmental and crystalline limestone, which ranges in thickness from 2.5 metres in the No. 1 well to 10 metres in the No. 3 well. The core indicates sub-vertical fracturing throughout, complemented by scattered pinpoint and vuggy porosity. Light coloured packstones and grainstones of the Sulphur Point appear to be representative of a middle fore-slope reefal environment.

Surface exploration identified a northeast-southwest trending fault. A two-fold seismic survey and a structure test hole program confirmed closure of about 85 metres.

An area of 3177 hectares is assigned to the reservoir in SDL 11 based upon geological and geophysical interpretations done by the original operator and verified by the National Energy Board. Average net pay for the pool is based upon an average between O16 (3.0 metres) and B07 (4.0 metres). *Estimated reserves are 18 Bcf.* These locations are in Significant Development Licence 109.

*Grumbler G63*
Favourable conditions for Slave Point reservoir development resulted from differential drape over the underlying Keg River, which had already been uplifted, and then faulted by Laramide tectonics which further increased the elevation and closure of the reservoir. This late episode of faulting may explain the extensive fracturing and lost circulation in the reservoir. Much of the porosity appears to be from fine fractures that are evident in the samples; intergranular porosity is poor to fair. Dense limestone of the upper Slave Point and shales of the Waterways cap the Slave Point gas reservoir.

The Grumbler G63 well was drilled on a Keg River seismic anomaly. Isochron thickening in the Keg River to Precambrian interval was used to identify a seismic feature, which was thought to be a Keg River reef. A reflection identified as Slave Point carbonate drapes over the interpreted anomaly.

Porosity averages 11% across 6 metres of pay in the Slave Point. *Estimated reserves are 1.9 Bcf.* This land is not currently under licence.

*Kakisa Lake F35*
The pay zone at F35 is found in a porous zone developed at the top of the Slave Point. Core recovered across the pay zone displays a highly fossilferous packstone with amphipora, thamnopora and stromatoporoids. Intergranular porosity is fair but there is also abundant pinpoint and vuggy porosity. Widely dispersed pyrobitumen plugs some of the pore space, but this is more than offset

by the voids that appear to have been created by secondary processes. Porosities of up to 17% and permeabilities to 1.2 darcies were recorded through core analysis.

The original seismic rationale for drilling the three Kakisa Lake wells is uncertain. No publicly released seismic data is available that predates the drilling of F35. Early field mapping suggested the possibility of several isolated highs along a syncline (graben?) that trends northeast-southwest.

Average porosity for the 6-metre thick pay zone is 9%. *No reserves have been calculated for this location* due to the lack of seismic delineation or other control. Roughly 1 Mmcf/d was tested from the Slave Point Formation on a drill stem test. The land is not currently under licence.

## Other Potential

Potential exists for a number of other play types in the region. For example, a possible pinnacle reef was identified within the Keg River Formation when the Grumbler G63 well was drilled. Although that zone was wet, Keg River pinnacle reefs in more favourable structural positions could be found. Presqu'ile reefs beyond the barrier front, as found in northeastern B.C. at Yoyo/Sierra, could also be good prospects.

Stratigraphic traps are possible for the Sulphur Point (as found at Bistcho in northern Alberta) where dolomitic grainstones and packstones were deposited in peritidal channels. In those settings trapping would be provided by organic-rich Watt Mountain shale.

Coarse crystalline Presqu'ile dolomite, with high porosity and permeability is distributed along a northeast-southwest fault trend. Favourable structures could provide prolific production similar to the Manetoe dolomite in the foothills of the Fort Liard area.

Basal Clastic deposits on the Precambrian unconformity are also present in the area. These clastic deposits provide good oil reservoirs in similar tectonic settings on the Peace River Arch in Alberta and elsewhere in the world in extensional basins. Other possibilities may exist where the granitic basement is deeply weathered and porosity has been enhanced.