



GEOLOGICAL SURVEY OF CANADA

OPEN FILE 5572

Hydrocarbon Assessment Summary Report of Willow Lake, Kelly Lake, Bear Rock, and The Smokes Areas of Interest

Y. Lemieux

2007



Natural Resources
Canada

Ressources naturelles
Canada

Canada

GEOLOGICAL SURVEY OF CANADA

OPEN FILE 5572

Hydrocarbon Assessment Summary Report of Willow Lake, Kelly Lake, Bear Rock, and The Smokes Areas of Interest

Y. Lemieux¹

2007

©Her Majesty the Queen in Right of Canada 2007
Available from
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8

¹Geological Survey of Canada, Northwest Territories Geoscience Office, Box 1500, 4601-B 52 Avenue, Yellowknife, Northwest Territories, Canada, X1A 2R3

Lemieux, Y.

2007: Hydrocarbon Assessment Summary Report of Willow Lake, Kelly Lake, Bear Rock, and The Smokes Areas of Interest, Geological Survey of Canada, Open File 5572, 15 p.

Open files are products that have not gone through the GSC formal publication process.

ABSTRACT	1
INTRODUCTION	1
GEOLOGICAL SETTING	2
HYDROCARBON OCCURRENCES	3
HYDROCARBON PROSPECTIVITY	4
Cambrian Sandstone play (established/conceptual)	4
Siluro-Ordovician play (conceptual)	5
Lower Devonian play (conceptual)	5
Middle Devonian play (conceptual)	5
Cretaceous play (conceptual)	6
Qualitative and quantitative estimates of hydrocarbon potential	6
FUTURE WORK	7
ACKNOWLEDGEMENTS	7
REFERENCES	8

ABSTRACT

The purpose of this report is to present a hydrocarbon resource potential assessment of Willow Lake, Kelly Lake, Bear Rock, and The Smokes areas of interest. The four areas examined here are located in the central Mackenzie Valley, and together cover an area in excess of 1000 km². The central Mackenzie Valley is underlain by a succession of folded and thrust-faulted resistant Paleozoic carbonate and siliciclastic rocks overlain by a thin veneer of Mesozoic and Tertiary clastic units; some of the units are prospective for oil and gas. Two exploration wells have been drilled within Willow Lake area of interest. No exploration wells have been drilled within Kelly Lake, Bear Rock or The Smokes areas of interest. This report suggests that the overall petroleum potential of Willow Lake, Kelly Lake, Bear Rock, and The Smokes areas is probably low to moderate.

INTRODUCTION

The NWT Protected Areas Strategy (PAS) is a partnership process to establish protected areas in the Northwest Territories. The PAS process requires that as areas are identified, the known cultural, ecological and economic values are studied, documented and discussed. As part of this work, Non-Renewable Resource Assessments of mineral and hydrocarbon potential are conducted on areas of interest. The purpose of this report is to present a hydrocarbon resource potential assessment of Willow Lake, Kelly Lake, Bear Rock, and The Smokes areas of interest, which are part of the Tulita Conservation Initiative (TCI) of PAS. The TCI includes various ecologically and culturally important areas within the Tulita District. The four areas examined here are located in the central Mackenzie Valley (Fig. 1), and together, cover an area in excess of 1000 km²; they cover parts of NTS map sheets 096 C, E, and F.

Willow Lake area of interest is located north of Tulita and occupies an area of approximately 700 km² (Fig. 2). The area is recognized for its critical waterfowl habitat and important karst topography. It includes a small part of the Mackenzie Plain and Franklin Mountains physiographic regions, as well as Brackett Lake and Brackett River. Most of Willow Lake area of interest lies at an elevation of 122 m (400 feet) above sea level, with highlands in excess of 213 m (700 feet) along its eastern boundary. The area lies between 125°34'W and 125°05'W longitude, and south of 65°17'N latitude; Great Bear River defines its southern limit.

Kelly Lake area of interest is located northeast of Norman Wells and covers approximately 300 km² (Fig. 2). The area contains important habitat for moose and waterfowl, and provided generations of people with rich hunting grounds. It includes a small part of the Franklin Mountains and is bounded to the north, west and east by Kelly Lake and associated drainage, and by Oscar Creek and the Discovery Ridge of Norman Range to the south. Kelly Lake area of interest lies at an average elevation of 610 m (2000 feet), with highlands to the southwest of Kelly Lake rising above 731 m (2400 feet).

Bear Rock area of interest covers about 30 km² and is located at the southern tip of Norman Range (Fig. 2). It lies 6 km west of Tulita, on the north bank of the Mackenzie River. Its elevation ranges from 91 m to 457 m (300-1500 feet). The Smokes area of interest is a small area of ~ 0.2 km² located 4 km east of Tulita on the north bank of the Mackenzie River (Figs. 2). Most of The Smokes area of interest lies at an elevation of 76 m (250 feet). These two areas encompass culturally important features for the community of Tulita.

The Norman Wells Oil Pipeline and the right-of-way for the proposed Mackenzie Valley Gas Pipeline extend along Willow Lake, Kelly Lake, Bear Rock, and The Smokes areas of interest (Fig. 1).

GEOLOGICAL SETTING

The Franklin Mountains, underlying Kelly Lake area of interest, are characterized by an arcuate series of linear low ridges external to the Mackenzie Mountains that reach 1600 m in elevation. They comprise a succession of folded and thrust-faulted resistant Paleozoic carbonate and siliciclastic rocks overlain by a thin veneer of Mesozoic and Tertiary clastic units (Fig. 3). The Paleozoic succession, which overlies Proterozoic rocks of the Mackenzie Mountains Supergroup, includes Cambrian clastic rocks and evaporites (Mount Clark, Mount Cap, and Saline River formations; Table 1) overlain by a succession of Ordovician to Devonian carbonate rocks (Franklin Mountain, Mount Kindle, Tsetso, Camsell, Arnica, Landry (Bear Rock), Kee Scarp, and Hume formations; Table 1) and clastic rocks (Hare Indian, Canol, and Imperial formations; Table 1). Cretaceous and Tertiary strata overlie the Paleozoic succession and include the Martin House, Arctic Red, Slater River, Little Bear, East Fork, and Summit Creek formations.

PERIOD (Epoch, stage)		FORMATION / GROUP	LITHOLOGY
Tertiary	Paleocene	Summit Creek	Conglomerate, sandstone
Cretaceous	Upper	East Fork	Shale
		Unconformity	
		Little Bear	Sandstone
		Slater River	Shale, sandstone
		Unconformity	
	Lower	Arctic Red	Shale
		Martin House	Sandstone, siltstone
Unconformity			
Devonian	Upper	Imperial	Shale, siltstone, sandstone
		Canol	Black shale
	Middle	Kee Scarp	Limestone
		Hare Indian	Shale
		Hume	Limestone
	Lower	Landry (Bear Rock)	Limestone (breccia)
		Arnica (Bear Rock)	Dolostone (breccia)
		Camsell	Dolostone
		Tsetso	Dolostone, siltstone, sandstone
Unconformity			
Ordovician-Silurian		Mount Kindle	Dolostone
Unconformity			
Cambrian-Ordovician		Franklin Mountain	Dolostone
Cambrian	Lower-Middle	Saline River	Evaporite, red beds
		Unconformity	
		Mount Cap	Shale
		Mount Clark	Sandstone
Unconformity			
Precambrian	Proterozoic	Mackenzie Mountains	Siliciclastic rocks

Table 1. Main rock formations of the Mackenzie Plain and Franklin Mountains.

The succession is punctuated by two major unconformities: the great sub-Phanerozoic, or sub-Cambrian unconformity marking the base of the Paleozoic succession, and the sub-Cretaceous separating Cretaceous strata from the underlying Paleozoic strata.

Willow Lake, Bear Rock and The Smokes areas of interest are located in the Mackenzie Plain, a broad, rolling, drift-mantled and tree-covered region within which the Mackenzie River is entrenched. The sedimentary succession exposed in the Franklin Mountains to the east extends westward beneath the Mackenzie Plain.

The Franklin Mountains form the eastern limit of the Cordillera. Deformation in the Franklin Mountains and Mackenzie Plain mostly occurred during the post-Paleocene Laramide tectonic event, but earlier, Cretaceous phase(s) of deformation have also been documented in the Franklin Mountains (MacLean and Cook, 1999). On the basis of seismic survey data and exploration wells, a regional paleotectonic feature termed Keele Arch (Cook, 1975) has been interpreted to extend from the Keele River northward. The Keele Arch is about 300 km along its north-south axis and more than 100 km wide, and underlies most of the area covered in this report (Figs. 4, 5). It developed in the Middle Ordovician, was marked by episodes of uplift and subsidence until pre-Cretaceous time (MacLean, 2006), and controlled in a regional sense the distribution of Paleozoic strata in the central Mackenzie Valley (Williams, 1989). Along the axis of the Keele Arch, Cambrian to Devonian units are either unusually thin or absent. At the PCI K'alo B-62 well located within Willow Lake area of interest (see below), the entire Devonian succession is absent and Cretaceous strata directly overlie Ordovician rocks.

HYDROCARBON OCCURRENCES

Table 2 summarizes exploration drilling results for petroleum resources in the seven wells drilled within or immediately adjacent to Willow Lake, Kelly Lake, Bear Rock, and The Smokes areas of interest (Fig. 3). Two exploration wells have been drilled within Willow Lake area of interest. No drill stem tests (DSTs) for oil and gas were reported for PCI K'alo B-62 well. At the Aquit Brackett Lake C-21 well, DSTs performed within the Franklin Mountain Formation yielded mud.

No exploration wells have been drilled within Kelly Lake, Bear Rock or The Smokes areas of interest. Four wells (Ranger Bear Rock O-20, NSM Bluefish A-49, Imperial Canol Bluefish (No.1A) A-37, and NSM Windy Island A-53) were drilled less than 6 km south and/or west of Bear Rock area of interest. One well (Discovery Ridge D-04) was drilled 3 km west of Kelly Lake area of interest. DSTs performed at the Ranger Bear Rock O-20 well yielded water. The other four wells were either not tested or yielded unsuccessful DSTs.

This is a negative result with respect to petroleum prospectivity. This assessment is solely based on a few wells drilled within, or adjacent to, the areas of interest, and as such it is reasonable to argue that the areas have not been adequately tested. The absence of any hydrocarbons recorded from petroleum exploration drilling does not preclude the possibility of significant petroleum potential in this region.

The most significant discovery in the Mackenzie Plain/Franklin Mountain area occurred at Norman Wells. The Norman Wells field, located approximately 15 km southwest of Kelly Lake area of interest (Fig. 3), was discovered in 1920; it is still one of the top producing oil fields in Canada. The field has an estimated 679 million barrels of oil and 220 billion cubic feet (Bcf) of solution gas in place (Canadian Gas Potential Committee, 2005).

Well name and Grid number	Location of well	Completion Date	Total Depth (m)	Lowest Formation Reached	Status of well
Imperial Canol Bluefish (No.1A) A-37 6500-12545	West of Bear Rock area	1943/10/20	1079.0	Fort Norman (Arnica equivalent)	Dry and abandoned
NSM Bluefish A-49 6500-12545	West of Bear Rock area	1984/12/20	1305.0	Saline River	Dry and abandoned
NSM Windy Island A-53 6500-12530	South of Bear Rock area	1985/02/09	1495.7	Delorme (Tsetso equivalent)	Dry and abandoned
PCI K'alo B-62 6520-12515	Within Willow Lake area	1986/03/18	1985.0	Mount Clark	Dry and abandoned
Aquit Brackett Lake C-21 6520-12500	Within Willow Lake area	1973/03/01	1536.5	Franklin Mountain	Dry and abandoned
Discovery Ridge D-04 6530-12645	West of Kelly Lake area	1999/01/24	461.2	Hare Indian	Dry and abandoned
Ranger Bear Rock O-20 6500-12545	Northeast of Bear Rock area	1998/03/02	249.0	Hume	Dry and abandoned

Table 2. Summary of wells drilled within, or adjacent to, Willow Lake, Kelly Lake, Bear Rock, and The Smokes areas of interest. See Fig. 3 for location of wells.

HYDROCARBON PROSPECTIVITY

The area north of Tulita and east of Norman Wells is underlain by Paleozoic and Mesozoic rocks that are prospective for oil and gas. The Canadian Gas Potential Committee (2001, 2005; see also Gal, 2005; Gal and Udell, 2005) defined several hydrocarbon plays in the central Mackenzie Valley area that could potentially host oil and/or natural gas.

Five of these exploration plays occupy portions of Willow Lake, Kelly Lake, Bear Rock, and The Smokes areas of interest (Figs. 4, 5). These stratigraphically defined plays include the “Cambrian Sandstone”, “Siluro-Ordovician”, “lower Devonian”, “middle Devonian”, and “Cretaceous” plays. In the following discussion, no distinction is drawn between plays occurring in the Interior Plains versus plays extending into the Cordilleran “Disturbed Belt” west of the Interior Plains. It should be understood that prospects in the Interior Plains are generally more stratigraphically controlled, whereas structural features tend to dominate those in the “Disturbed Belt” (e.g., Hannigan et al., 2006).

Cambrian Sandstone play (established/conceptual)

This play includes all the prospects and discovered pools in structural traps in the porous Cambrian quartz sandstone of the Mount Clark Formation; this formation has proven to be a good reservoir rock as it hosts natural gas in the Colville Hills area. The Cambrian Sandstone “fairway” is considered an established¹ play by the Canadian Gas Potential Committee (2005; see also Gal and Udell, 2005) and extends as far south as Kelly Lake (Fig. 4). Elsewhere in the central Mackenzie Valley, the Cambrian Sandstone play is conceptual² (Cambrian Sandstone “play” on Fig. 4). Hydrocarbon source beds for this play occur in the overlying shale and siltstone of the Mount Cap Formation (Dixon and Stasiuk, 1998). These source rocks range from immature to mature in the Colville Hills area where gas discoveries occur. Stasiuk and Fowler (2002) published maturity data for stratigraphically higher Middle Devonian strata in the central

¹ An established play has been demonstrated to exist by the discovery of hydrocarbon pools

² A conceptual play does not yet have discoveries or reserves, but may exist according to geological analysis

Mackenzie Valley area; extrapolation of their data suggests that the level of organic maturity of Cambrian source rocks probably ranges from immature in Kelly Lake and Willow Lake areas of interest to mature with respect to the oil generating window in Bear Rock and The Smokes areas of interest.

Hydrocarbon reservoir rocks of the Mount Clark Formation are regionally widespread within the northern and central portion of the Mackenzie Valley. In excess of 46 m of Mount Clark Formation have been drilled in B-62 well; isopach maps suggest, however, that the Mount Clark Formation pinches out rapidly to the south and west of the area covered in this report (Dixon and Stasiuk, 1998), and therefore may not be an adequate reservoir.

Siluro-Ordovician play (conceptual)

Hydrocarbon might be present in porous and vuggy Ordovician-Silurian carbonate rocks of the Franklin Mountain and Mount Kindle formations. Top seals for this play include anhydrite of the Bear Rock Formation, or possibly younger impermeable intervals. Oil was locally recovered from fractured Franklin Mountain Formation at the East Mackay B-45 well located ~20 km south of Tulita, where Cretaceous shale provided a source and seal.

Along the Keele Arch, pre-Devonian and pre-Mesozoic erosion removed much of the Franklin Mountain and Mount Kindle formations. Franklin Mountain Formation sandstone has been encountered at PCI K'alo B-62, Aquit Brackett Lake C-21, and NSM Bluefish A-49 wells, and reaches a thickness in excess of 500 m in places. The overlying Mount Kindle Formation, however, is absent from all three wells.

Extrapolation of maturity data for Middle Devonian strata (Stasiuk and Fowler, 2002) suggests that the level of organic maturity probably ranges from immature in Kelly Lake and Willow Lake areas of interest to mature with respect to the oil generating window in Bear Rock and The Smokes areas of interest. The absence of good organic source rock facies in strata immediately above or below Siluro-Ordovician strata is a substantial play risk factor.

Lower Devonian play (conceptual)

This play includes all the prospects and pools in stratigraphic and structural traps hosted in vuggy dolostone of the Arnica Formation and solution breccia of the Bear Rock Formation. Possible stratigraphic traps include porous dolostone and brecciated intervals inter-fingered with tight carbonates and evaporites, whereas structural traps may include fault-bounded closure and folded beds (Canadian Gas Potential Committee, 2005).

Reservoir rocks of the Arnica and Bear Rock formations are regionally widespread; along the trend of the Keele Arch, however, they have been removed by pre-Cretaceous erosion in places (e.g., Devonian strata are absent from the succession at PCI K'alo B-62 well).

This stratigraphic interval yielded oil and gas at the Summit Creek B-44 well, located approximately 70 km south of Tulita (Husky Energy news release, Oct. 12, 2005). Although few details regarding this discovery have been published, it is likely that the dolostone of the Arnica Formation and breccia of the Bear Rock Formation form the reservoir there. Overlying, Middle Devonian (and younger) argillaceous intervals of the Hare Indian Formation and Canol Formation most likely acted as the reservoir seal and also as the organic source rock for hydrocarbons.

Middle Devonian play (conceptual)

This play includes all the prospects and discovered pools in stratigraphic and structural traps hosted in reef build-ups and biostromes within the Hume and Hare Indian formations. This play includes the Kee Scarp limestone reefs, which is the reservoir of the Norman Wells field. Traps may be stratigraphic, such as the Norman Wells field, or structural, involving overthrust sheets and normal faulting within the Franklin Mountains. The Hume Formation is generally a non-porous facies but structurally induced fracturing may have enhanced porosity here.

Source rocks include the organic-rich basal unit of the Hare Indian Formation (Bluefish Member) and the overlying Canol Formation shale. Rock-eval pyrolysis studies of samples from the Bluefish Member, Hare Indian Formation, and Canol Formation at the C-21 well yielded Tmax values between 430 and 441°C, within the oil generating window (Feinstein et al., 1988). Cuttings from the Hare Indian Formation at A-37 yielded well Tmax of 444 and 448°C, also within the oil generating field (Feinstein et al., 1988).

Maturity data for Middle Devonian strata (Stasiuk and Fowler, 2002) suggests that the level of organic maturity probably ranges from immature in Kelly Lake and Willow Lake areas of interest to mature with respect to the oil generating window in Bear Rock and The Smokes areas of interest.

Cretaceous play (conceptual)

Potential reservoir rocks could be present in Cretaceous sandstone overlying the Paleozoic succession. At Stewart D-57 well located in the Stewart Lake area north of Keele River, Husky Energy recently drilled through a hydrocarbon-bearing horizon within Cretaceous rocks (Husky Energy news release, May 17, 2006).

Prospective reservoirs include the basal sandstone of the Slater River Formation, and sandstone within the Little Bear and Summit Creek formations (Dixon, 1999). The Cretaceous Slater River Formation shale is a potential source rock for the Upper Cretaceous sand. Extrapolation of thermal maturation data of Stasiuk and others (2002) indicates that Cretaceous organic-rich source rocks within the area of interest are marginally mature with respect to the oil generation window. This suggests that generation of large volume of hydrocarbons within the area is unlikely.

Because of the occurrence of reservoir facies at shallow depth, there is an increased risk of reservoir breaching and degradation of hydrocarbons by meteoritic or ground water. Also, in some areas of interest, Cretaceous strata are either very thin or absent.

Qualitative and quantitative estimates of hydrocarbon potential

The Canadian Gas Potential Committee (2005) estimated that 7.5 trillion cubic feet (Tcf) of natural gas remains to be discovered across the entire Cambrian Sandstone play. Only a very small portion of this estimate i.e., probably less than 0.1 Tcf could be expected within the areas of interest discussed here.

The hydrocarbon potential map of the Sahtu and Gwich'in settlement regions of Gal (2005; Fig. 6) provides a comparative and qualitative assessment based on a number of geological factors, such as the number of overlapping petroleum plays, the presence of established plays and (or) known hydrocarbon for any given area. Play boundaries and other criteria used are largely based on reconnaissance level studies and are subject to interpretation. The assessment presented here is merely a guide and should be used with caution.

Mainly based upon the presence of the established Cambrian Sandstone play across the area of interest, Gal (2005) assigned a "Very High" petroleum potential rating to most of Kelly Lake area of interest; the southwestern portion of the area was assigned a "Low to Moderate" rating. Although a portion of undiscovered natural gas across the Cambrian Sandstone play could be expected here (see above), the rating of Gal (2005) for most of Kelly Lake area may be optimistic. On the basis of geological factors discussed above, a low to moderate rating is probably more realistic.

Gal (2005) assigned a "Low to High" petroleum potential rating, from west to east, across Willow Lake area of interest, reflecting the absence of prospective units above the Keele Arch; a "Moderate to High" petroleum potential was assigned to Bear Rock and The Smokes areas of interest. As previously discussed, the area along the axis of the Keele Arch is marked by either absent or unusually thin lower Paleozoic potential reservoir and source rocks. Also, some of the

prospective intervals are either shallow or exposed at surface, increasing the risk of reservoir breaching, and (or) flushing and degradation of hydrocarbons by meteoritic or ground water. As such, a low to moderate petroleum potential rating for Willow Lake, Bear Rock, and The Smokes areas of interest is probably more reasonable.

FUTURE WORK

Oil and gas potential of the Mackenzie Valley and surrounding areas is the focus of a Northern Energy project under the Secure Canadian Energy Supply program of the Geological Survey of Canada. The main objective of this multidisciplinary project is to assess the hydrocarbon resource potential of the Mackenzie Valley using quantitative and qualitative geoscience data. Key outputs will be a series of Open File reports that outline the petroleum potential across the Mackenzie Valley. Resource estimates will be available by 2009.

ACKNOWLEDGEMENTS

Dave Morrow critically reviewed this report. Northwest Territories Geoscience Office Contribution #0030.

REFERENCES

Canadian Gas Potential Committee 2001: Natural Gas Potential in Canada, 2001; CD-ROM.

Canadian Gas Potential Committee 2005: Natural Gas Potential in Canada, 2005; CD-ROM.

Cook, D.G. 1975: The Keele Arch, a pre-Devonian and pre-Late Cretaceous Paleo-upland in the Northern Franklin Mountains and Colville Hills; Geological Survey of Canada, Paper 75-1, Part C, p. 243-246.

Dixon, J. 1999: Mesozoic-Cenozoic stratigraphy of the Northern Interior Plains and Plateaux, Northwest Territories; Geological Survey of Canada, Bulletin 536, 56 p.

Dixon, J., and Stasiuk, L.D. 1998: Stratigraphy and hydrocarbon potential of Cambrian strata, Northern Interior Plains, Northwest Territories; Bulletin of Canadian Petroleum Geology, v. 46, p. 445-470.

Feinstein, S., Brooks, P.W., Gentzis, T., Goodarzi, F., Snowden, L.R., and Williams, G.K. 1988: Thermal maturity in the Mackenzie Corridor, Northwest and Yukon Territories, Canada; Geological Survey of Canada, Open File 1944, 23 p.

Gal, L.P. 2005: Hydrocarbon potential ranking map of the Sahtu and Gwich'in settlement areas, hydrocarbon play map of the Sahtu and Gwich'in settlement areas; Northwest Territories Geoscience Office, NWT Open File 2005-04, 2 maps, scale 1:1,000,000.

Gal, L.P., and Udell, A.J. 2005: Compiled Hydrocarbon Play Polygons for mainland Northwest Territories, ArcView[®] .shp format files: Sahtu Settlement Area, Gwich'in Settlement Area, mainland Inuvialuit Settlement Region, Dehcho territory; Northwest Territories, Canada; Northwest Territories Geoscience Office, NWT Open Report 2005-004, 27 p.

Hannigan, P.K., Dixon, J., and Morrow, D.W. 2006: Oil and Gas potential of the northern mainland, Canada (Mackenzie Corridor and northern Yukon); Geological Survey of Canada, Open File 5343, 58 p.

MacLean B.C. 2006: GIS-enabled subsurface time and depth structure maps, Cambrian to Cretaceous, Great Bear and Mackenzie plains, Northwest Territories; Geological Survey of Canada, Open File 5327, 11 p.

MacLean B.C. and Cook, D.G. 1999: Salt tectonism in the Fort Norman area, Northwest Territories, Canada; Bulletin of Canadian Petroleum Geology, v. 47, p. 104-135.

Morrow, D.W., Jones, A.L., and Dixon, J. 2006: Infrastructure and resources of the Northern Canadian Mainland Sedimentary Basin; Geological Survey of Canada, Open File 5152, 1 CD-ROM.

Stasiuk, L.D., and Fowler, M.G. 2002: Thermal maturity evaluation (vitrinite and vitrinite reflectance equivalent) of Middle Devonian, Upper Devonian and Mississippian strata in Western Canada Sedimentary Basin; Geological Survey of Canada, Open File 4341 (CD).

Stasiuk, L.D., Fowler, M.G., and Addison, G. 2002: Thermal maturity evaluation of Lower Cretaceous Manville Group and Equivalent Coals in the Western Canada Sedimentary Basin; a compilation of vitrinite reflectance data; Geological Survey of Canada, Open File 4342 (CD).

Wheeler, J.O., and McFeely, P. 1991: Tectonic Assemblage map of the Cordillera and adjacent parts of the United States of America; Geological Survey of Canada, Map 1712A, scale 1:2,000,000.

Williams, G.K. 1989: Tectonic evolution of the Fort Norman Area, Mackenzie Corridor, N.W.T.; Geological Survey of Canada, Open File 2045, 44 p.

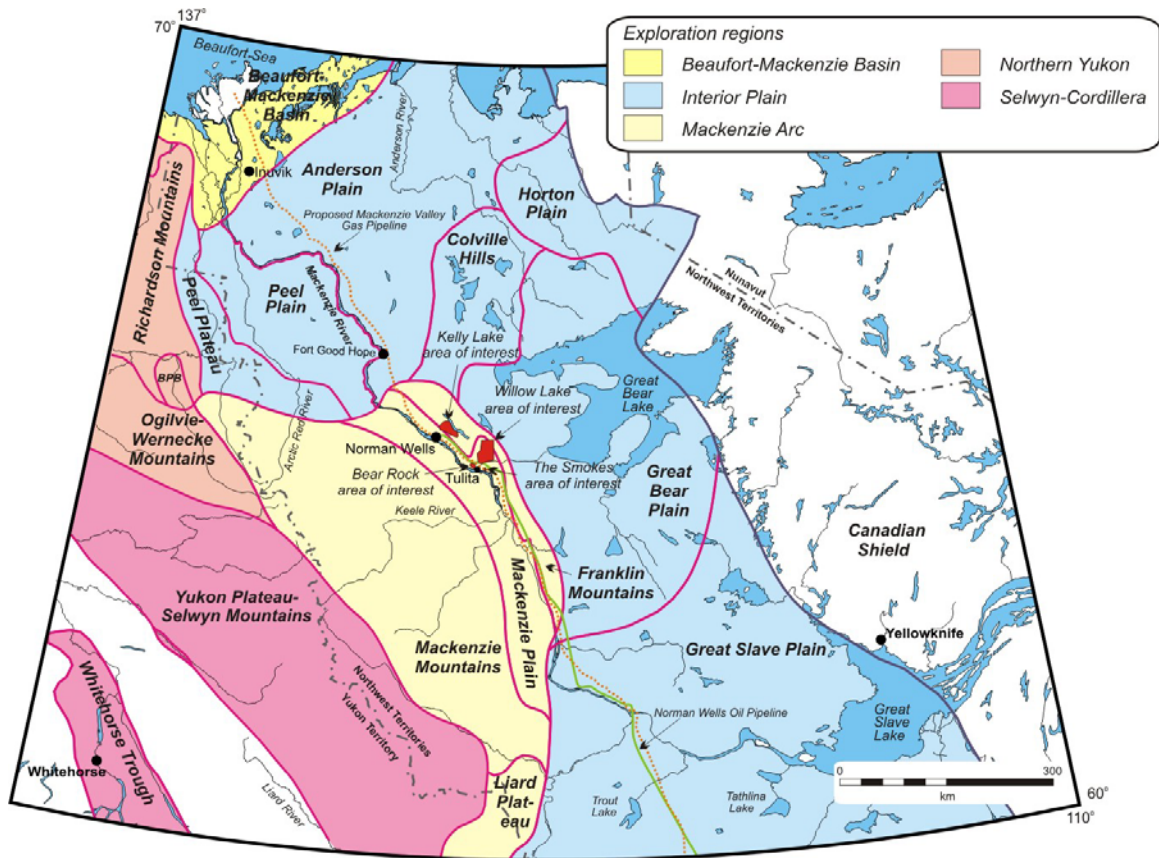


Figure 1. Main exploration regions of the Mackenzie Valley. Exploration regions are subdivided into exploration areas (e.g., Great Slave and Great Bear plains) on the basis of physiographic and/or geologic features. Figure shows the location of Willow Lake, Kelly Lake, Bear Rock, and The Smokes areas of interest. BPB, Bonnet Plume Basin. Modified from Morrow et al. (2006).

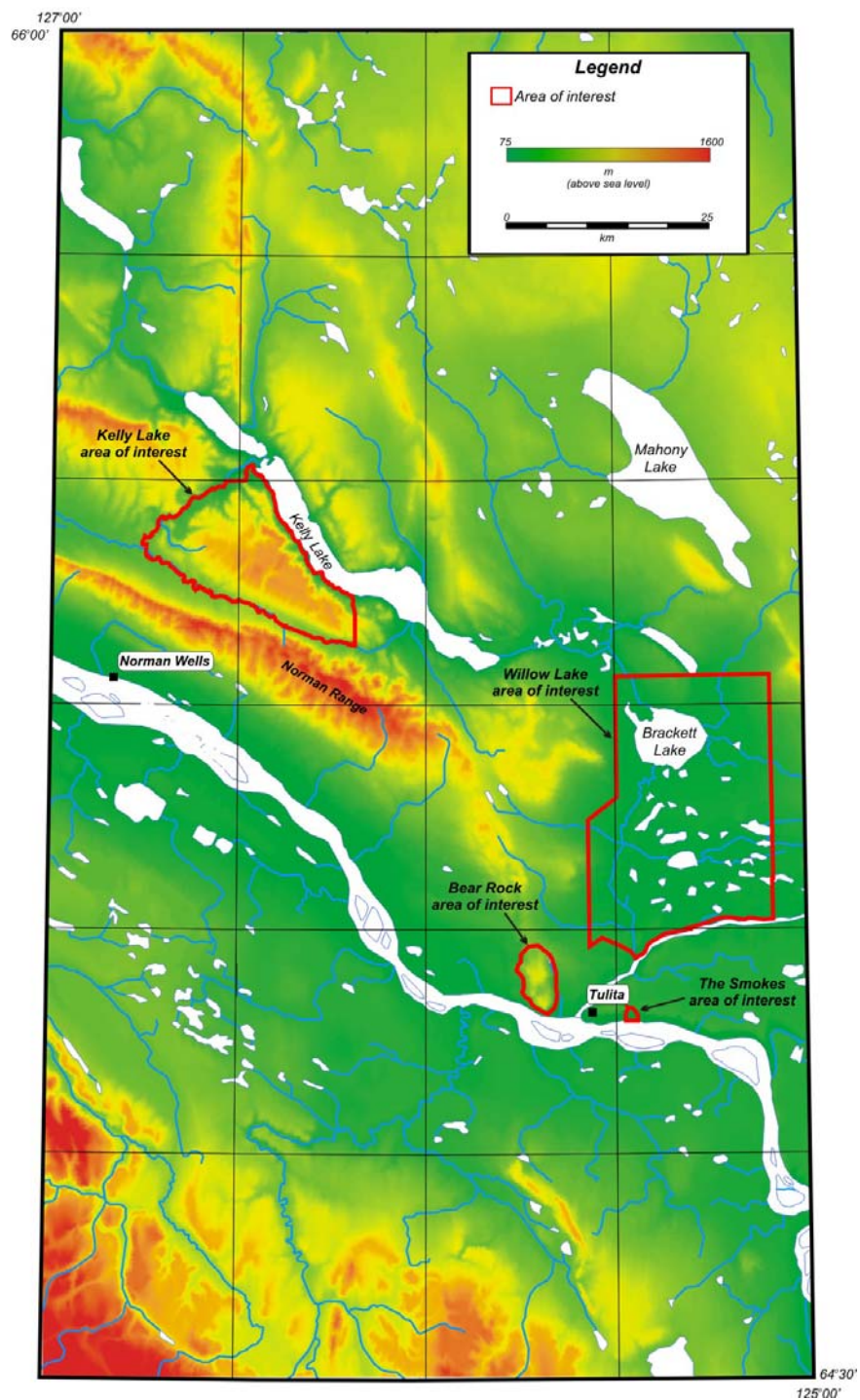


Figure 2. Elevation map of the central Mackenzie Valley including Willow Lake, Kelly Lake, Bear Rock, and The Smokes areas of interest.

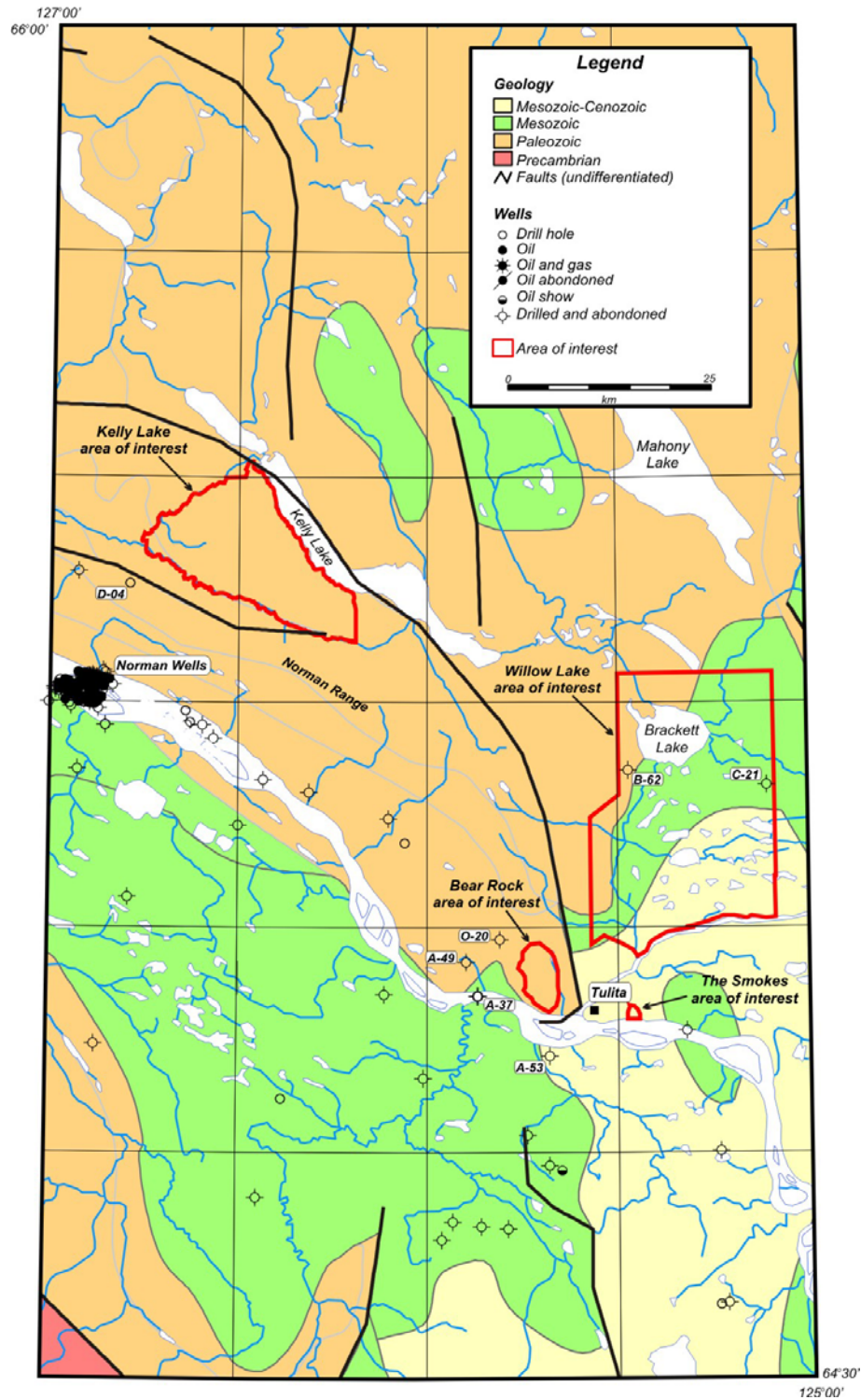


Figure 3. General geology map of the central Mackenzie Valley. The map shows the location of wells discussed in the text. The area comprises a succession of folded and thrust-faulted Paleozoic carbonate and siliciclastic rocks overlain by a thin veneer of Mesozoic and Tertiary clastic units. Geology modified after Wheeler and McFeely (1991).

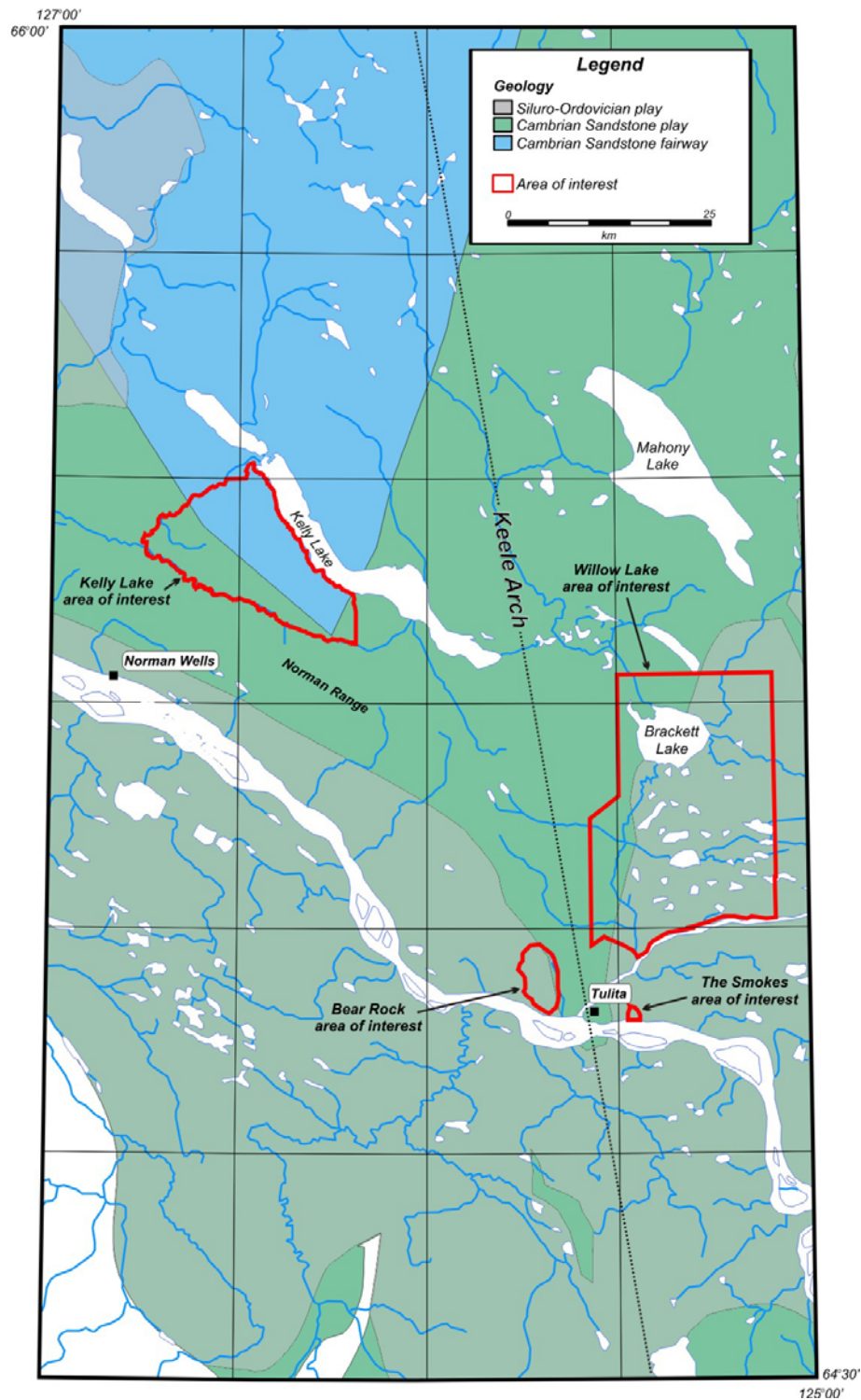


Figure 4. Map of the Cambrian Sandstone play and fairway, and Siluro-Ordovician play underlying Willow Lake, Kelly Lake, Bear Rock, and The Smokes areas of interest. The figure shows the location of the axis of the Keele Arch. Hydrocarbon play polygons from Canadian Gas Potential Committee (2001, 2005) and Gal and Udell (2005).

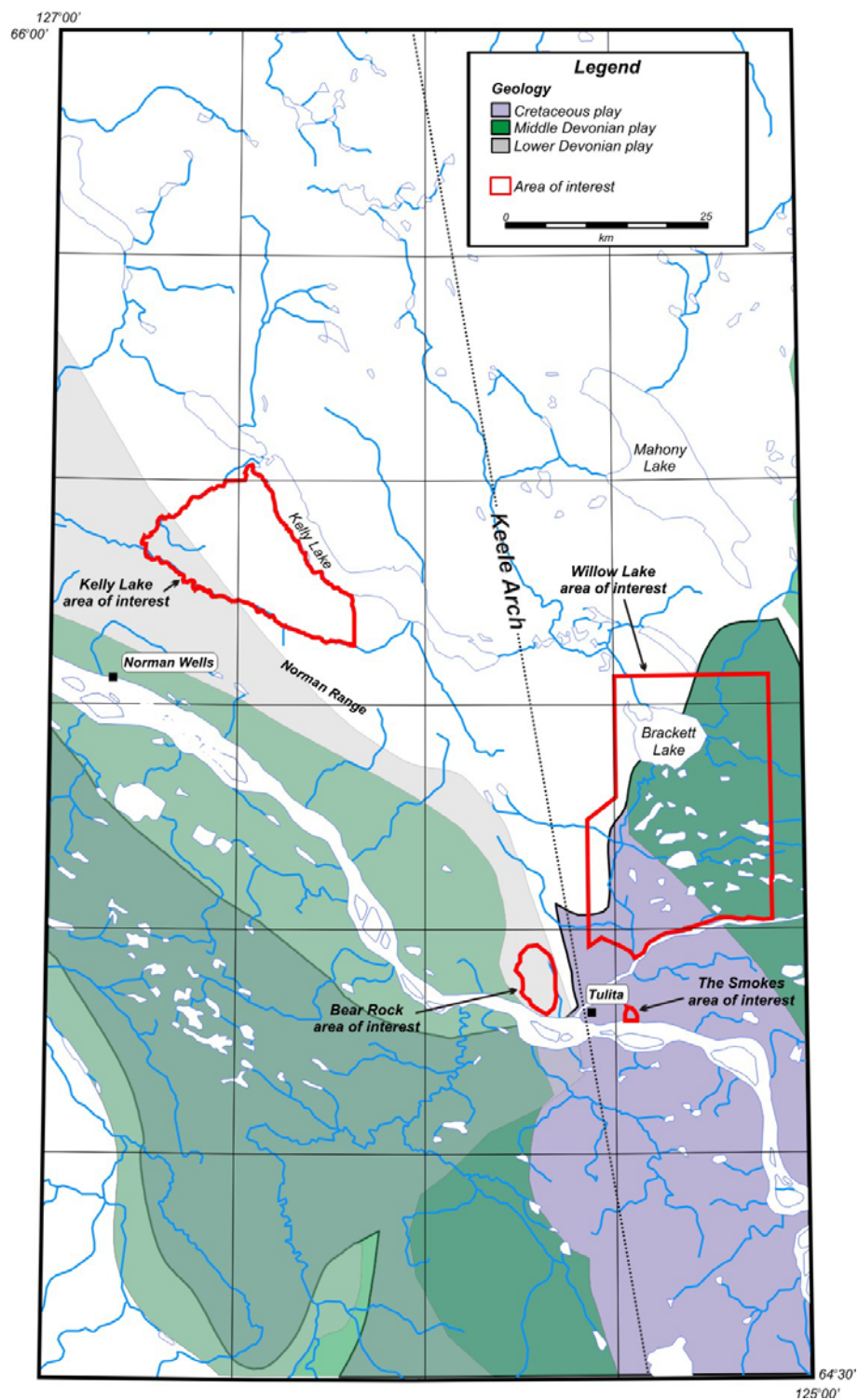


Figure 5. Map of the lower Devonian, middle Devonian, and Cretaceous plays underlying Willow Lake, Kelly Lake, Bear Rock, and The Smokes areas of interest. The figure shows the location of the axis of the Keele Arch. Hydrocarbon play polygons from Canadian Gas Potential Committee (2001, 2005) and Gal and Udell (2005).

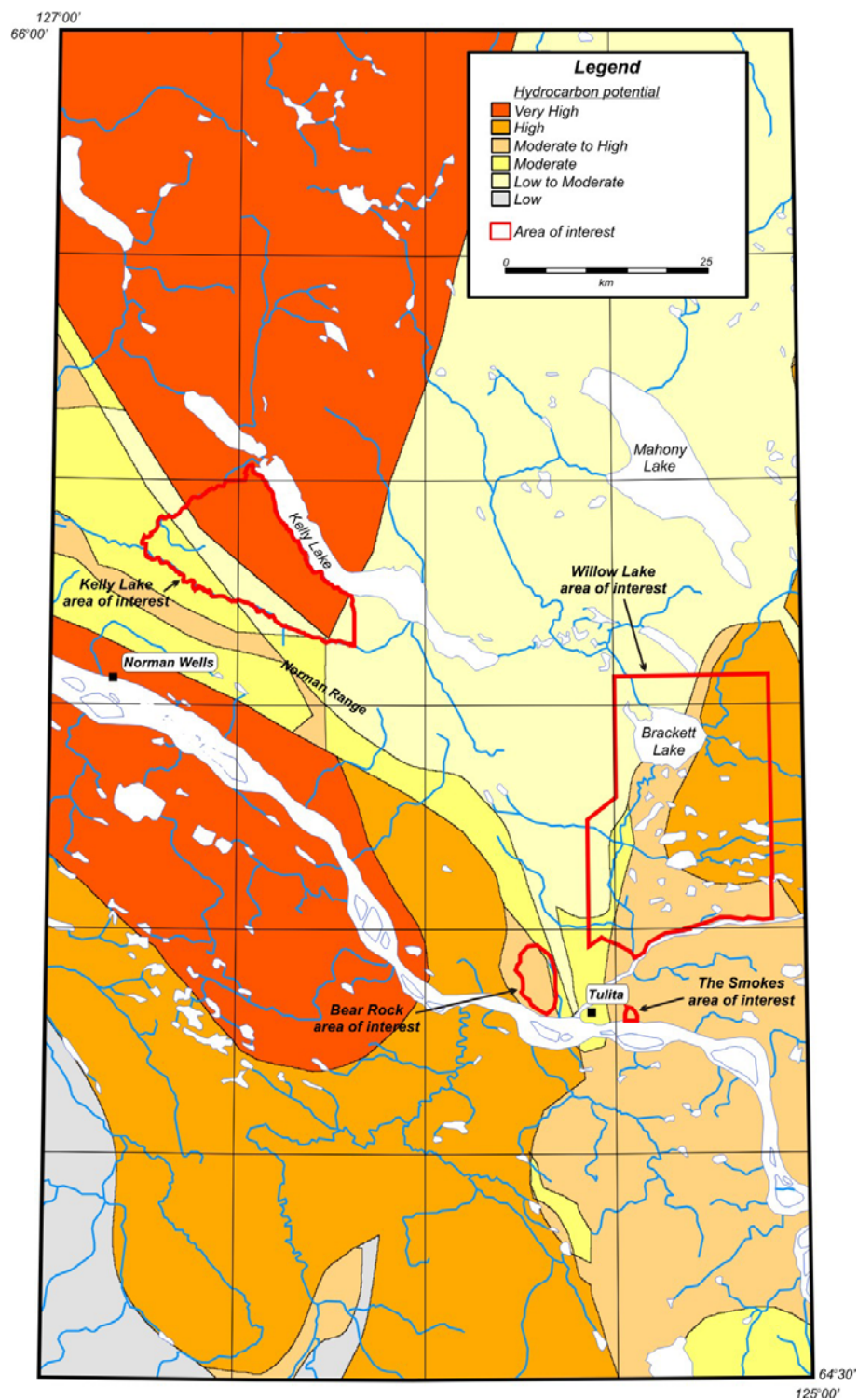


Figure 6. Hydrocarbon potential map of Willow Lake, Kelly Lake, Bear Rock, and The Smokes areas of interest. The areas of interest are shown to have a petroleum potential ranging from “Low” to “Very High” (Gal, 2005). Subsequent work suggest that the overall petroleum potential of Willow Lake, Kelly Lake, Bear Rock, and The Smokes areas of interest would be better characterized as low to moderate. See text for discussion. Figure modified from Gal (2005).