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Hydrocarbon Assessment Summary Report of Mountain River, Keele River, Ravensthroat/Redstone River, and Drum Lake Areas of Interest

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ABSTRACT

The objective of this report is to present a hydrocarbon resource potential assessment of Mountain River, Keele River, Ravensthroat/Redstone River, and Drum Lake areas of interest. The four areas examined here are located in the Mackenzie Mountains, and together cover an area in excess of 25,000 km^2. The geology of the Mackenzie Mountains is characterized by uplifted, faulted and folded Proterozoic, Paleozoic and Mesozoic carbonate and siliciclastic rocks. Although adequate potential source and reservoir rocks are present throughout the Mackenzie Mountains, their overall hydrocarbon potential is low. Because much of the potential reservoirs are exposed at surface, there is an increased risk of reservoir breaching, or flushing and/or degradation of hydrocarbons by meteoritic or ground water. Much of Mountain River, Keele River, Ravensthroat/Redstone River, and Drum Lake areas of interest have low hydrocarbon potential; the potential is higher where the areas of interest are underlain by the Plateau Overthrust play.

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 objective of this report is to present a hydrocarbon resource potential assessment of Mountain River, Keele River, Ravensthroat/Redstone River, and Drum Lake 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. Mountain River and Keele River area of interest provide important caribou calving grounds and sheep habitat; Ravensthroat/Redstone River follows historic traditional trails of the Mountain Dene. The areas of interest examined in this report are located in the Mackenzie Mountains (Fig. 1), and together, cover an area in excess of 25,000 km^2. Because the various regions of the Mackenzie Mountains share a similar geological history, the hydrocarbon potential of the four areas of interest can be discussed under this report.

Mountain River area of interest is approximately 10,000 km^2 and is bounded by Mountain River and associated drainage to the north, and by the Northwest Territories/Yukon border to the west; it extends as far south as 63°00'N latitude (Figs. 1, 2). The southern half of Mountain River area of interest is restricted by the Backbone Ranges to the east. Elevation ranges between 915 m up to ~2300 m (3000-7500 feet). The area covers parts of NTS map sheets 105 O, P, and 106 A, B, and H.

Keele River area of interest covers approximately 8,500 km^2; the area forms a 40 km wide zone situated along the Keele River (Figs. 1, 2). It is bounded by Mountain River area of interest to the west, and extends as far east as 125°43'W longitude. Its elevation ranges from approximately 300 m up to 2300 m (1000-7500 feet). It covers parts of NTS map sheets 95 M, 96 C and D, 105 I and P, and 106 A.

Ravensthroat/Redstone River area of interest is approximately 7,000 km^2 and forms a 40 km wide corridor along the Ravensthroat and Redstone rivers (Figs. 1, 2). It encompasses the headwaters of both rivers, and is located between 128°00'W and 125°28'W longitude. Its elevation ranges between 600 m and 2130 m (2000-7000 feet). Ravensthroat/Redstone River area of interest covers parts of NTS map sheets 95 L, M, and N.

Drum Lake area of interest is a small area (~ 250 km^2) within Ravensthroat/Redstone River area of interest (Figs. 1, 2). Drum Lake area of interest encompasses Wrigley Lake. It lies at an average elevation of ~ 760 m (2500 feet), with highlands above 1060 m (3500 feet). It covers parts of NTS map sheets 95 M and N.

PERIOD (Epoch, stage)		FORMATION / GROUP (West/east of Mackenzie Arch)		LITHOLOGY
Cretaceous	Early	Unnamed sandstone and siltstone		
Unconformity				
Devonian	Late	Imperial		Shale, siltstone, sandstone
		Canol		Black shale
	Middle	Ramparts		Limestone
		Horn River	Hare Indian	Shale
		Hume		Limestone
	Early	Mount Baird	Landry (Bear Rock)	Shale / Limestone (breccia)
		Arnica (Bear Rock)		Dolostone (breccia)
		Camsell		Dolostone
		Tsetso		Dolostone, siltstone, sandstone
Unconformity				
Ordovician-Silurian		Whittaker	Mount Kindle	Dolostone and shale / Dolostone
Cambrian-Ordovician		Broken Skull	*Unconformity*	
			Franklin Mount.	Dolostone
Cambrian	Early-middle	Hess River	Saline River	Shale / Evaporite, red beds
			Unconformity	
		Sekwi	Mount Cap	Limestone / Shale
			Mount Clark	Limestone / Sandstone
		Vampire		Shale
		Backbone Rang.		Sandstone
Unconformity				
Precambrian	Proterozoic	Proterozoic undivided		Siliciclastic rocks

Table 1. Main rock formations of the Mackenzie Mountains.

GEOLOGICAL SETTING

The Mackenzie Mountains form an arcuate belt of deformed rocks along, and mostly east of, the Yukon-Northwest Territories border. The interior region of the Mackenzie Mountains is characterized by peaks and ridges up to 2800 m in elevation, which are cut by wide valleys and deep canyons.

The geology of the Mackenzie Mountains is characterized by uplifted, faulted and folded Proterozoic, Paleozoic and Mesozoic carbonate and siliciclastic rocks (Fig. 3). The Proterozoic succession in the Mackenzie Mountains largely consists of clastic rocks of the Katherine and Rapitan groups; the overlying Paleozoic succession includes Cambrian clastic rocks and evaporites overlain by Ordovician to Devonian carbonates and clastic rocks (Table 1). A regional paleo-topographic feature, termed Mackenzie Arch (e.g., Aitken et al., 1973, 1982; Williams, 1987), was prevalent along the axis of the Mackenzie Mountains in Cambrian time. It separated the platformal succession in the Mackenzie Plain depocentre to the east, from a deeper water

basinal succession in the Selwyn Basin to the west (Table 1; see Pyle et al., 2006 for a comprehensive discussion). The Cambrian succession is overlain by dolostone of the Franklin Mountain and Mount Kindle (and equivalent) formations. Platformal carbonates, organic-rich shale, and siltstones and sandstones compose the remainder of the Paleozoic succession in the Mackenzie Mountains. Cretaceous clastic units are found in places.

The evolution of the Mackenzie Mountains has been marked by a few tectonic events since the Precambrian (Aitken et al., 1982). The present morphology of the Mackenzie Mountains, marked by a series of east- and west-dipping high-angle fault, and concentric folds is, however, largely the result of the Late Cretaceous to Paleocene Laramide orogeny.

HYDROCARBON OCCURRENCES

Largely because of inaccessibility, no wells to date have been drilled in the northern Mackenzie Mountains, and most of the seismic coverage was acquired in the far eastern regions, in proximity to the Mackenzie Plain. In 2004, Husky Energy recovered gas and light oil at their Summit Creek B-44 well, located at the eastern edge of the Mackenzie Mountains, ~ 20 km east of Keele River area of interest (Husky Energy news release, Oct. 12, 2005). In 2006, Husky Energy also found gas in their Stewart D-57 well, located approximately 26 km east of Summit Creek B-44 well (Husky Energy news release, May 17, 2006). Prior to 2004, no wells drilled in the southern Mackenzie Mountains yielded significant hydrocarbon discoveries.

HYDROCARBON PROSPECTIVITY

Much of Mountain River, Keele River, Ravensthroat/Redstone River, and Drum Lake areas of interest are underlain by Proterozoic and Paleozoic rocks that are prospective for oil and gas. Numerous potential source rocks have been documented in the Mackenzie Mountains, including: 1) black shale in the Proterozoic Little Dal Group, 2) shale of the Cambrian Mount Cap Formation in the eastern Mackenzie Mountains, 3) shaly dolostone of the Lower Silurian Whittaker Formation, 4) organic-rich shale of the Devonian Hare Indian Formation (Bluefish Member) and Canol Formation, and 5) Cretaceous shale in the far eastern Mackenzie Mountains.

Potential reservoir rocks include: 1) carbonate and sandstone units in the Proterozoic Mackenzie Supergroup, 2) the Cambrian Mount Clark Formation in the eastern Mackenzie Mountains, 3) vuggy dolostone of the Franklin Mountain, Mount Kindle and Arnica formations (Bear Rock breccia), and 4) biohermal limestone of the Hume Formation in the northeastern Mackenzie Mountains (Hannigan et al., 2006; see also Canadian Gas Potential Committee, 2001, 2005).

Stasiuk and Fowler (2002) and Stasiuk and others (2002; see also Feinstein et al., 1988, 1991) published maturity data for Middle Devonian and Lower Cretaceous strata in the Mackenzie Valley area; extrapolation of their data suggests that the level of organic maturity of source rocks probably ranges from mature with respect to the oil generating window in the extreme eastern portion of the areas of interest, i.e., toward the Mackenzie Plain, to overmature (wet to dry gas generation zone) in much of the Mackenzie Mountains.

Gal (2005) produced a hydrocarbon potential map of the Sahtu and Gwich'in settlements area (Fig. 4). The comparative and qualitative assessment was based on the number of overlapping plays in subsurface for any given area; other assessment criteria, such as the geological favourability for the presence of hydrocarbon and the occurrence of established plays or known hydrocarbon accumulations were also considered (Gal and Udell, 2005). Play boundaries and other criteria used in Gal (2005) 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.

Although potential source and reservoir rocks are present throughout the Mackenzie Mountains, their overall hydrocarbon potential is low (Fig. 4; Gal, 2005; Hannigan et al., 2006).

Because much of the potential reservoirs are exposed at surface, there is an increased risk of reservoir breaching, or flushing and/or degradation of hydrocarbons by meteoritic or ground water. A few regions have been assigned a "Low to Moderate" petroleum potential. The Plateau Overthrust (Figs. 4, 5; Cecile et al., 1982) is a conceptual[1] play in which Proterozoic rocks have been thrusted over potential Paleozoic reservoir units. The area covered by this play exceeds 4,000 km^2 and overlaps with Mountain River, Keele River, Ravensthroat/Redstone River, and Drum Lake areas of interest. Potential source rocks in the footwall (i.e., below) of the thrust fault include Devonian organic-rich shale of the Bluefish Member and Canol Formation; potential reservoir rocks include Cambrian to Devonian carbonate units. No seismic or well data are available to help constrain the overall potential of this play. Surface samples are mature to overmature with respect to the oil window (Cecile et al., 1982).

The Cambrian Sandstone play (Fig. 5) includes all the prospects and discovered pools in structural traps in the porous Cambrian quartz sandstone of the Mount Clark Formation (Canadian Gas Potential Committee, 2001, 2005); this formation has proven to be a good reservoir rock as it hosts natural gas in the Colville Hills area. This plays mostly underlies the Interior Plains but extend into the eastern portion of the Mackenzie Arc and may overlap with the eastern portion of Keele River area of interest. 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; they are probably overmature near the front of the Mackenzie Mountains. Hydrocarbon reservoir rocks of the Mount Clark Formation are regionally widespread within the northern and central portion of the Mackenzie Valley; isopach maps suggest that the Mount Clark Formation pinches out rapidly toward the Mackenzie Mountains (Dixon and Stasiuk, 1998), and therefore may not be an adequate reservoir.

Summary of hydrocarbon potential

On the basis of geological factors discussed above, much of Mountain River, Keele River, Ravensthroat/Redstone River, and Drum Lake areas of interest have a low hydrocarbon potential (Fig. 4); the potential might slightly be higher where the areas of interest are underlain by the Plateau Overthrust or the Cambrian Sandstone plays. Several exploration risks, such as adequate source rocks, adequate seal, breaching of reservoir rocks, and timing of hydrocarbon generation are anticipated for these plays. Finally, regions characterized by intrusive rocks, i.e., the pale green areas on Fig. 4, have a very low hydrocarbon potential.

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 #0031.

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

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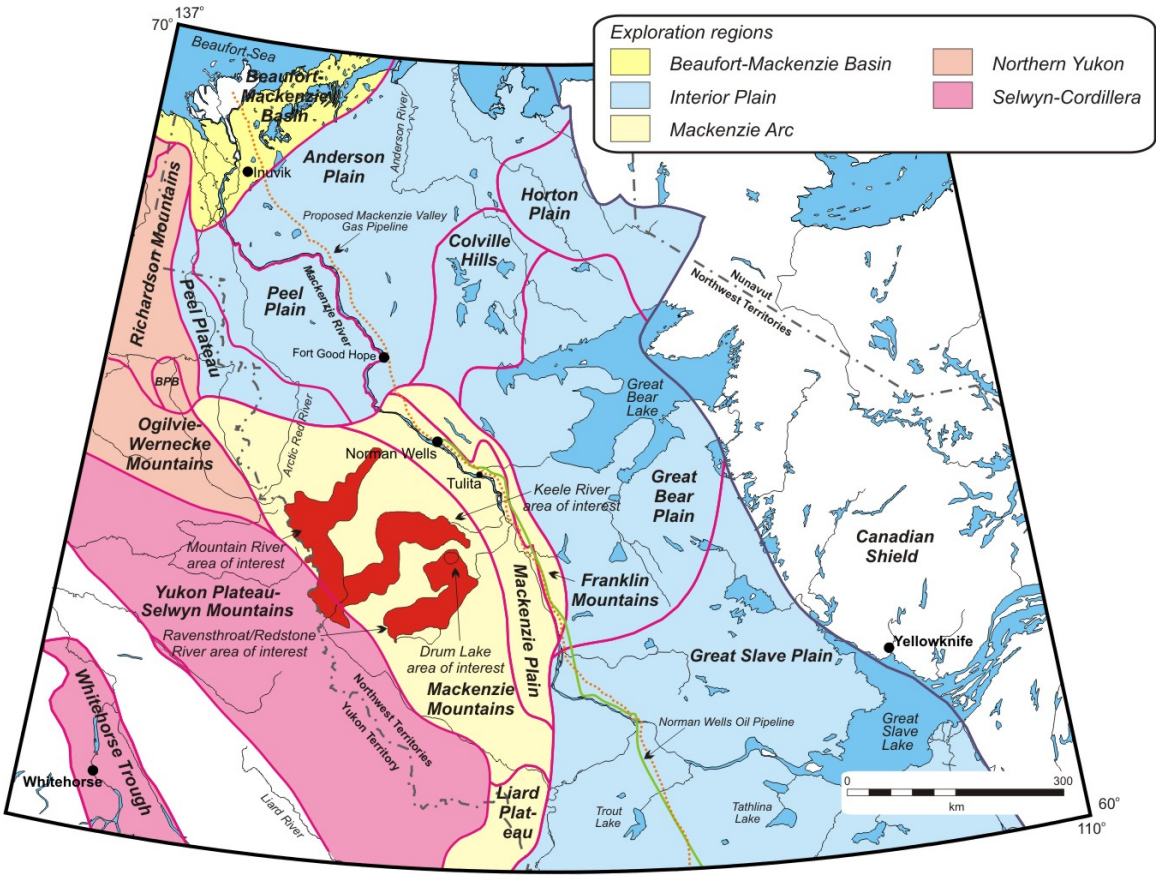

Figure 1. Main exploration regions of the Mackenzie Valley. Exploration regions are subdivided into exploration areas (e.g., Great Slave and Great Bear plains) on the basis of physiographic and/or geologic features. Figure shows the location of Mountain River, Keele River, Ravensthroat/Redstone River,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

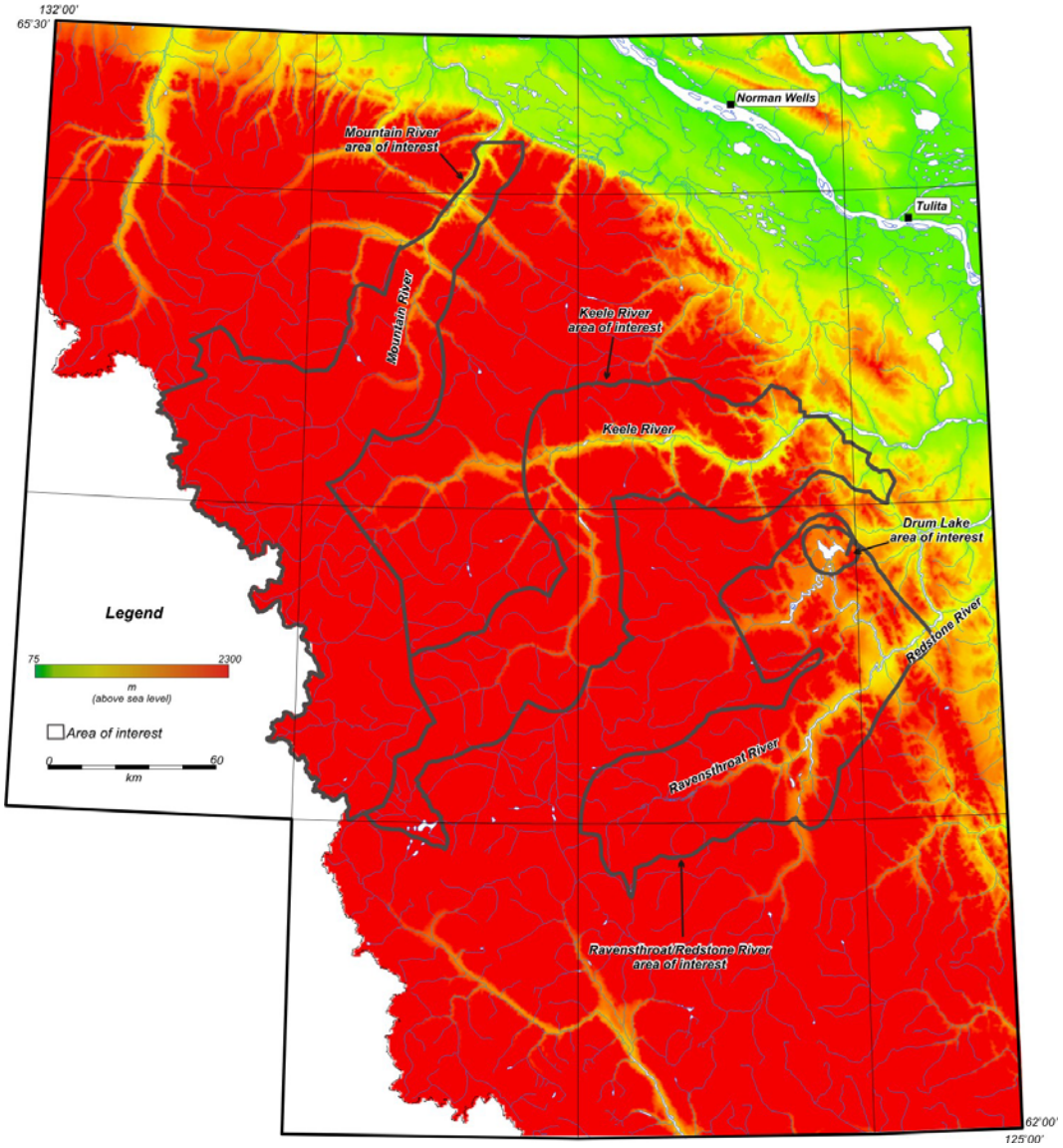

Figure 2. Elevation map of the Mackenzie Mountains including Mountain River, Keele River, Ravensthroat/Redstone River, and Drum Lake areas of interest.

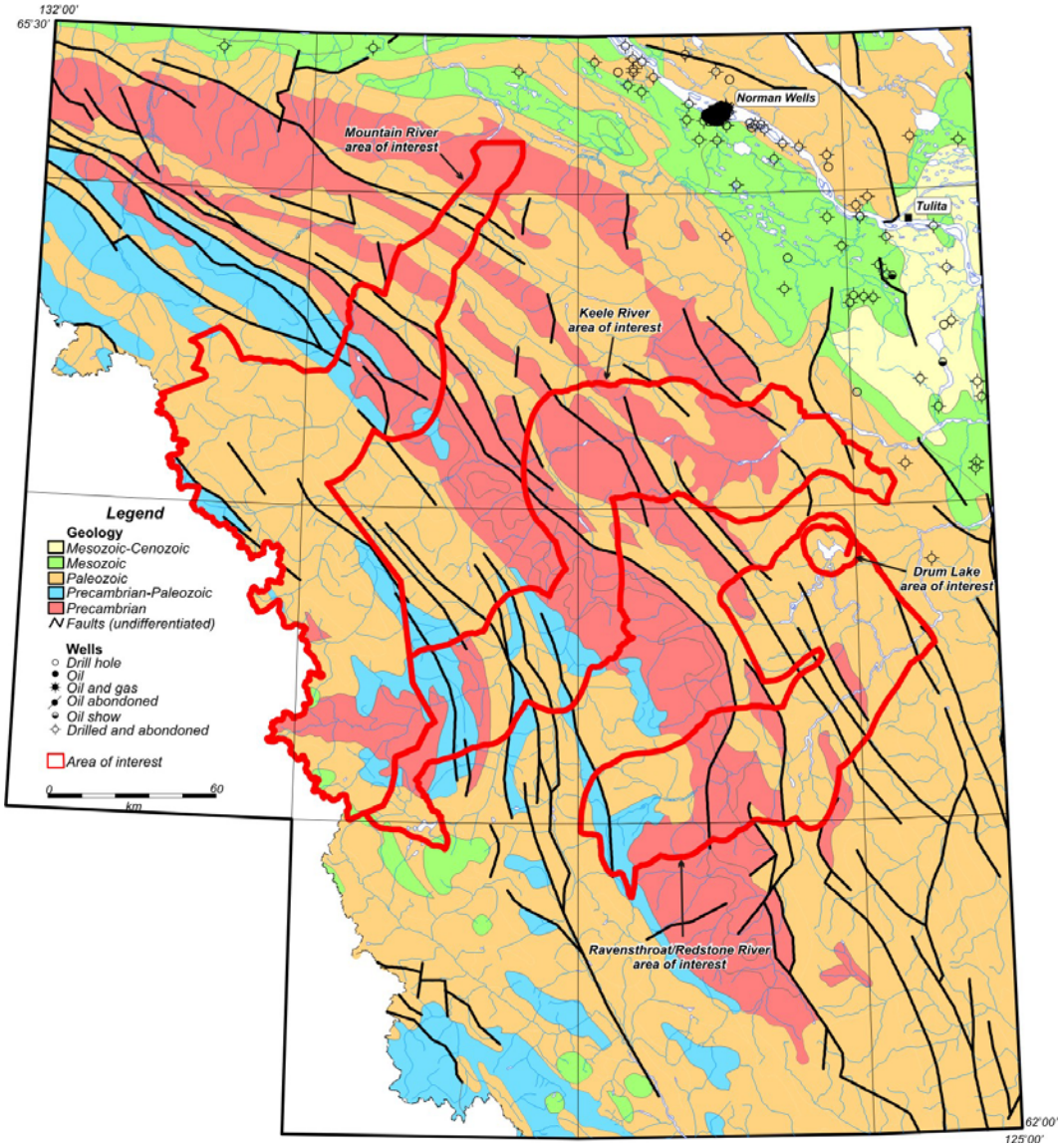

Figure 3. General geology map of the Mackenzie Mountains. The map shows the location of wells. The geology of the Mackenzie Mountains is characterized by uplifted, faulted and folded Proterozoic, Paleozoic and Mesozoic carbonate and siliciclastic rocks. Geology modified after Wheeler and McFeely (1991).

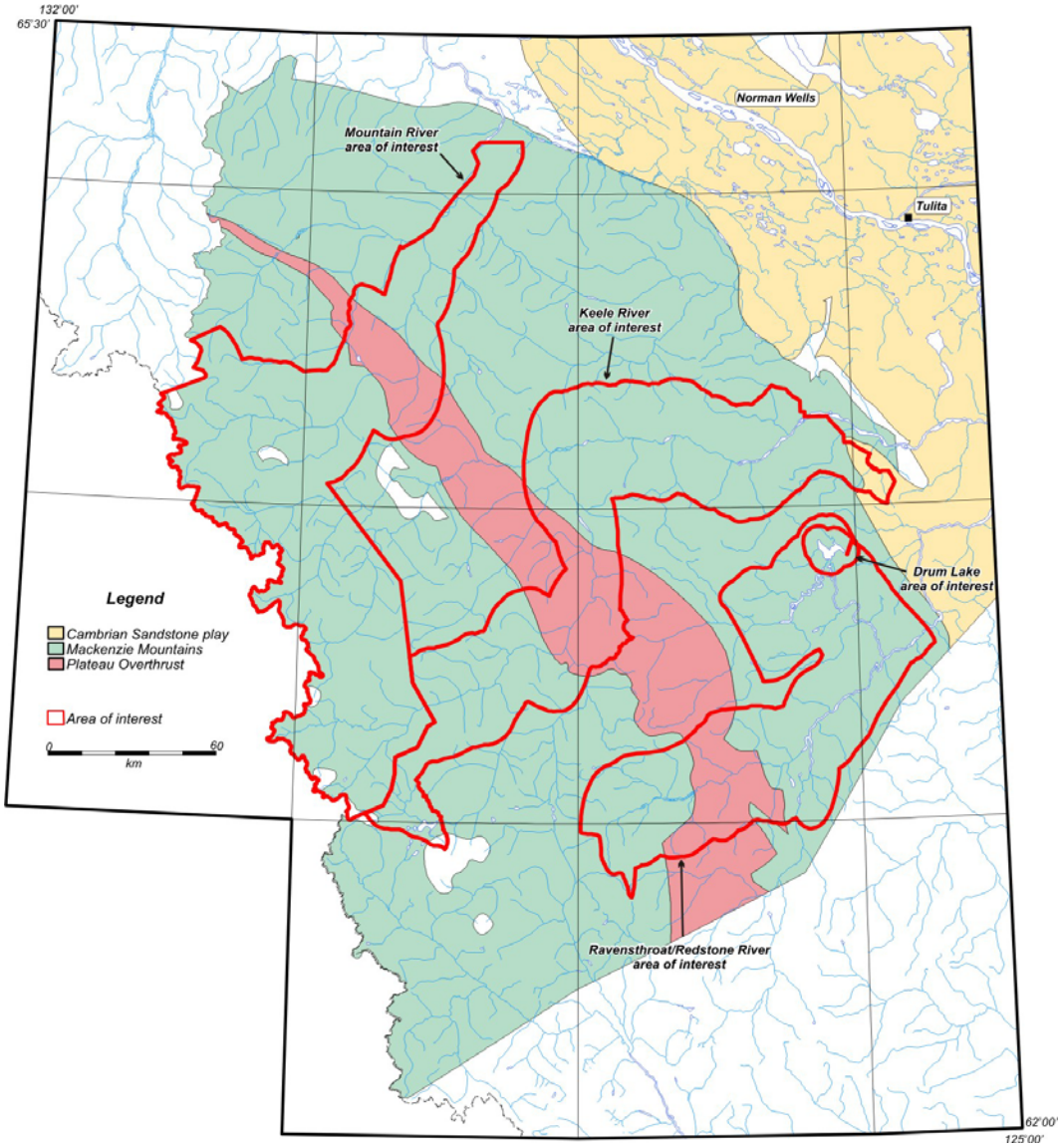

Figure 4. Hydrocarbon potential map of Mountain River, Keele River, Ravensthroat/Redstone River, and Drum Lake areas of interest. The areas of interest are shown to have a petroleum potential ranging from "Very Low" to "Low to Moderate" (Gal, 2005). See text for discussion. Figure modified from Gal (2005).

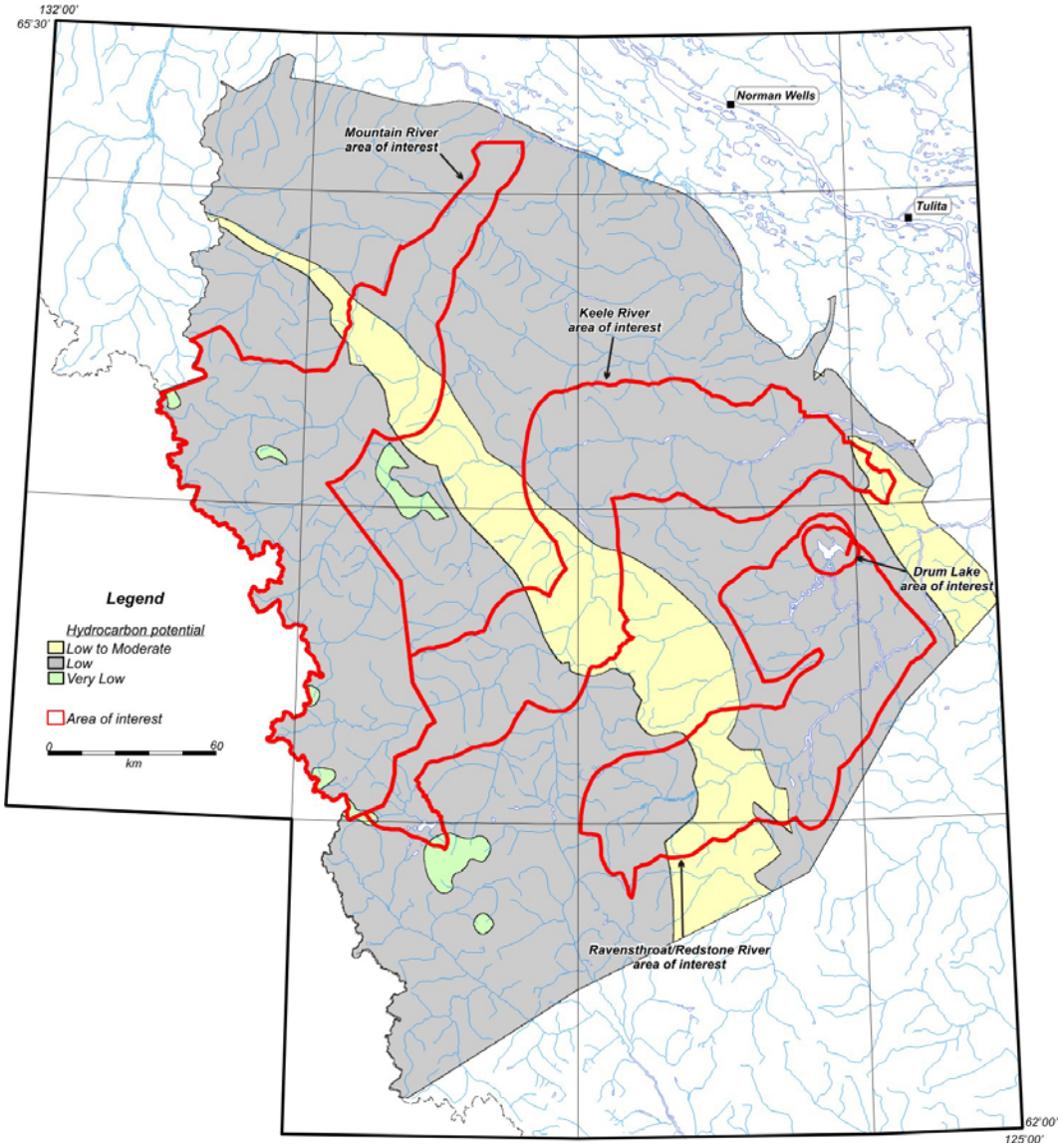

Figure 5. Map of the Cambrian Sandstone and Plateau Overthrust plays underlying Mountain River, Keele River, Ravensthroat/Redstone River, and Drum Lake areas of interest. On this map the plays are limited by the extent of the Sahtu territory. Hydrocarbon play polygons from Gal (2005) and Gal and Udell (2005).