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Edéhzhíe Candidate Protected Area Hydrocarbon Assessment Summary Report

D.W. Morrow

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ABSTRACT

The Edéhzhíe candidate protected area falls entirely within the Great Slave Plain physiographic region. Horn Plateau, a large upland area, is the dominant physiographic feature. Edéhzhíe has a low to moderate potential for natural gas and low oil potential. Quantitative estimates indicate that the ultimate potential of the Edéhzhíe candidate protected area is about 0.23 trillion cubic feet of natural gas. Devonian Horn Plateau reefs are the most prospective gas reservoirs, but some gas can also be expected to occur in underlying Paleozoic carbonates and the Cambrian Mount Clark sandstone in northeast Edéhzhíe. Oil potential is not significant and is about half a million barrels in the basal Cretaceous sandstones beneath Horn Plateau.

Introduction

The NWT Protected Areas Strategy (PAS) is a partnership process to establish 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 PAS areas of interest and candidate areas. A previous report (Gal and Lariviere, 2004) has reviewed and summarized both the petroleum and mineral resource potential of the Edéhzhíe candidate protected area in more detail than is presented here. The purpose of the present report is to focus on hydrocarbon resources and to present quantitative estimates of conventional[1] oil and natural gas potential.

Edéhzhíe occupies a large region of about 25,233 km^2 within the central part of Mackenzie Valley (Fig. 1) and extends between 61.31^o and 62.91^o N latitude and between 117.25^o and 123.14^o W longitude. Edéhzhíe falls largely within the Dehcho region south of the Sahtu Settlement Area in the Northwest Territories (Fig. 1). Edéhzhíe lies north of recognized gas pools and gas fields, such as the Cameron Hills gas field, that lie within 50 kilometres of the southern boundary of the Northwest Territories (see Gal and Jones, 2003). The Mink Lake gas pool (Gal and Jones, 2003) is a few kilometers east of Edéhzhíe. No recognized oil or gas pools lie within its borders (Fig.1).

Edéhzhíe lies entirely within the Great Slave Plain physiographic region of the Interior Plains of northern Canada immediately north and east of the Mackenzie River (Fig. 1; Bostock, 1970). Edéhzhíe is dominated by a large central upland area, the tree-covered Horn Plateau, which stands up to 825 metres elevation above a surrounding more marshy and tree-covered lowland lying between 100 and 300 metres above sea level (Fig. 2, 3). Most of Edéhzhíe is well drained and Horn Plateau has imposed a radial drainage pattern across most of the area with the exception of its narrow westward extension along the Willowlake River towards Mackenzie River (Fig. 2). Horn Plateau includes two large lakes, Hornell and Willow lakes. Bulmer Lake lies close to the north boundary of Edéhzhíe and Mills Lake occupies the extreme southeast corner. The western tip of Edéhzhíe extends up to the east bank of the Mackenzie River bordering the east flank of the Camsell Range which rises abruptly to elevations above 1200 metres (Fig. 2, 3, 4).

[1] Conventional oil and gas accumulations are defined by two key geologic characteristics: (1) they occupy limited, discrete volumes of rock bounded by traps, seals, and/or down-dip water contacts, and (2) they depend upon the buoyancy of oil or gas in water for their existence. Because of these properties, conventional accumulations are commonly assessed in terms of the sizes and numbers of discrete accumulations (for example, individual oil and gas fields).

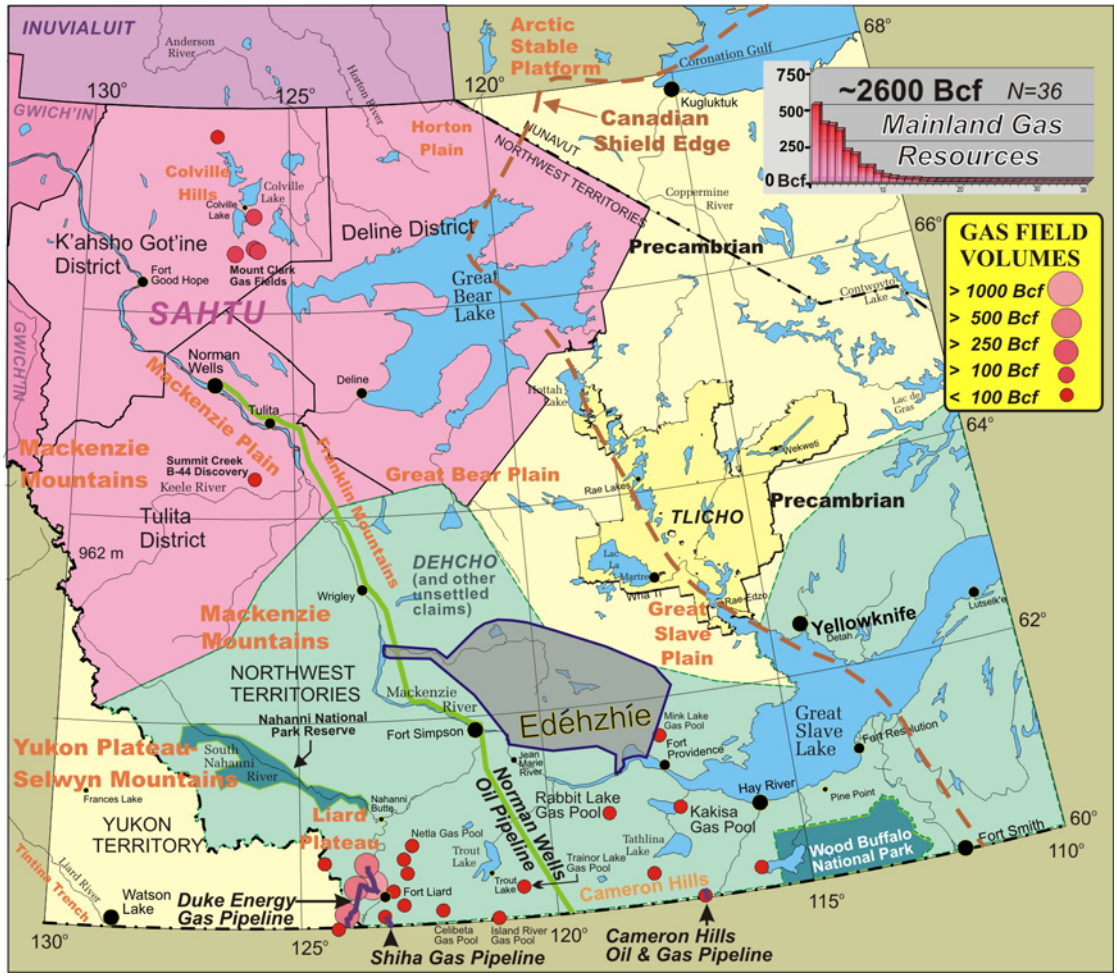

Figure 1. Discovered natural gas resources of the northern Canadian mainland (Morrow et al., 2006). The Edéhzhíe candidate protected area lies within the central Mackenzie Valley in the Dehcho region. It is a little over 200 kilometres southeast of the recent Summit Creek B-44 oil and gas discovery well (Unocal Corporation, 2005) and north of gas discoveries of the southern N.W.T.

No communities occur within the Edéhzhíe area, but the communities of Fort Simpson, Jean Marie River, and Fort Providence lie near the southern boundary (Fig. 2). These communities, and the more distant communities of Wrigley, Wha Ti and Rae/Edzo, are all sponsoring communities for the Edéhzhíe candidate protected area. The Norman Wells, or Enbridge, Oil Pipeline and the right-of-way for the proposed Mackenzie Valley Gas Pipeline extend along the east side of the Mackenzie River and across the extreme western tip of Edéhzhíe (Fig. 2).

Geological setting

The physiographic diversity within Edéhzhíe is characterized by correspondingly distinctive geology (Fig. 2, 3, 4, 5). Surface bedrock across Edéhzhíe, either exposed at surface or mantled with a thin cover of Quaternary glacial till and outwash (i.e. glacial drift; Table 1) and colluvium (Holocene) is composed of either lower Paleozoic shales, siltstones and bituminous limestones or by Cretaceous-aged shales, siltstones and sandstones (Fig. 5; Okulitch (in prep); 2006). Upturned, faulted and folded resistant Paleozoic carbonates (Arnica, Bear Rock, Landry, and Nahanni formations; Table 1) and siliciclastics (Tsetso and Headless formations) form the Camsell Range in the Franklin Mountains west of Edéhzhíe and the Mackenzie River. Middle to Upper Devonian siliciclastics of the Horn River, Fort Simpson, and the Redknife to Trout River formations, and unnamed calcareous shales, which are age-equivalent to the Tetcho and Kotcho formations farther southeast, are exposed across the small portions of the Mackenzie Plain lowlands that border the Camsell Range (Bostock, 1970).

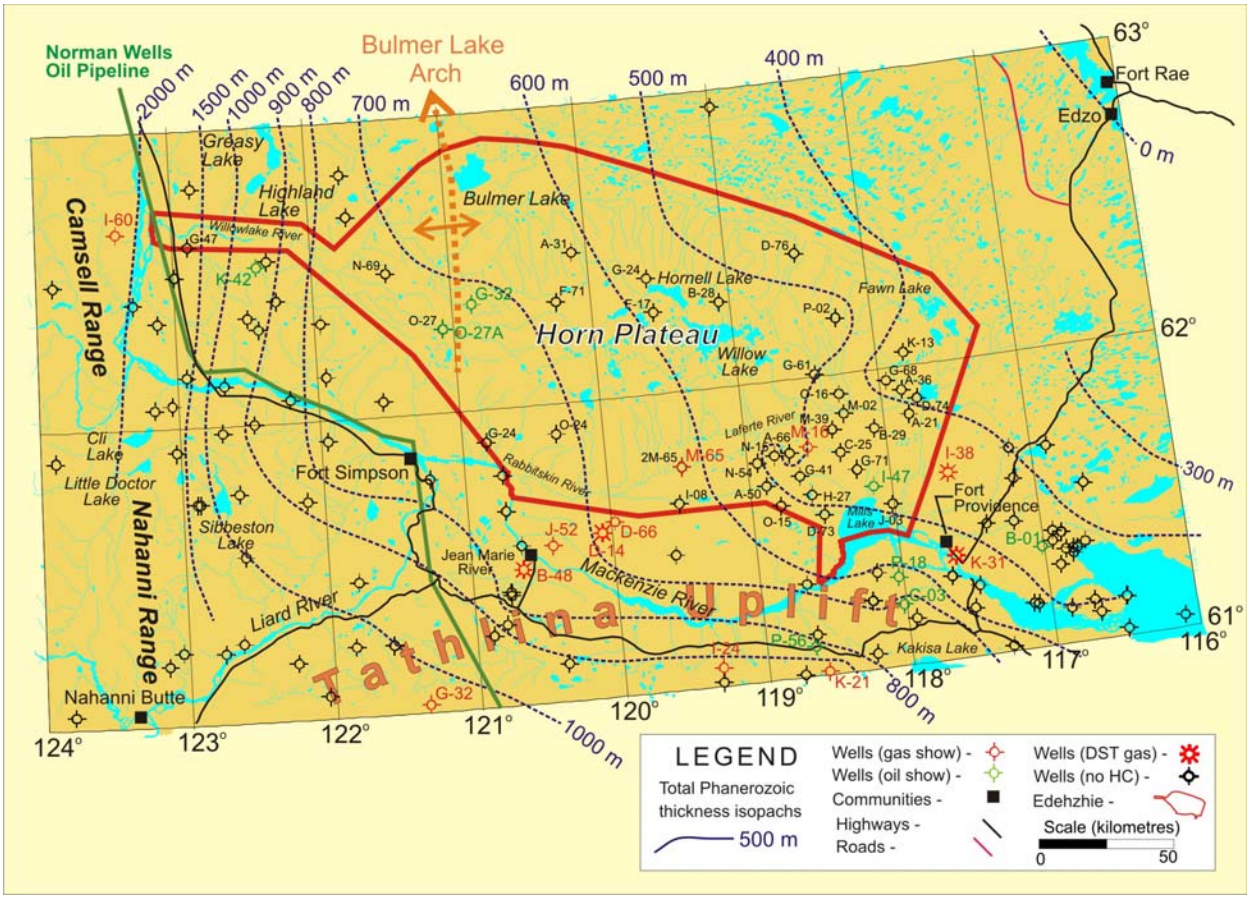

Figure 2. Petroleum exploration wells drilled in and around Edéhzhíe including gas discoveries (measured DST gas) and oil and gas shows. Also shows thickness of total Phanerozoic succession across Edéhzhíe and major early Paleozoic tectonic features. A Horn Plateau limestone reef is exposed at Fawn Lake on the east side of Edéhzhíe. The route for the proposed Mackenzie Gas Pipeline almost coincides with the route of the Norman Wells oil pipeline shown here.

Great Slave Plain is underlain by an overall gently southwestward-dipping and westward thickening succession of Phanerozoic sedimentary rocks unconformably overlying Precambrian sedimentary, metamorphic and igneous rocks that are commonly regarded as effective basement for the emplacement of economically recoverable hydrocarbons. However, there is some hydrocarbon prospectivity to the narrow strip of mid- to late Proterozoic sedimentary strata that underlie the Phanerozoic succession beneath the extreme western extension of Edéhzhíe (Fig. 6). The major sub-Phanerozoic unconformity is strikingly apparent at the base of the Phanerozoic succession (see Figure 13 in Gal and Lariviere, 2004).

Isopachs (or thickness contours) of the entire pre-Mesozoic Phanerozoic succession above Precambrian rocks and beneath Cretaceous strata are shown on Figure 2 (see also Gal and Lariviere, 2004). The Paleozoic succession thickens southwestward from about 350 metres on the east side of Edéhzhíe to about 2000 metres at its western edge (Fig. 2). Across most of Edéhzhíe, the Paleozoic thickness ranges from 400 metres to 800 metres in thickness (Fig. 2). The profound angular unconformity at the sub-horizontal base of the Cretaceous is strikingly apparent on the surface bedrock map where the Cretaceous strata that form Horn Plateau (see Fig. 2, 3 and 5) in the central part of Edéhzhíe directly overlie southwestward-dipping Devonian-aged strata of the Fort Simpson Formation and the Horn River Group (Fig. 5).

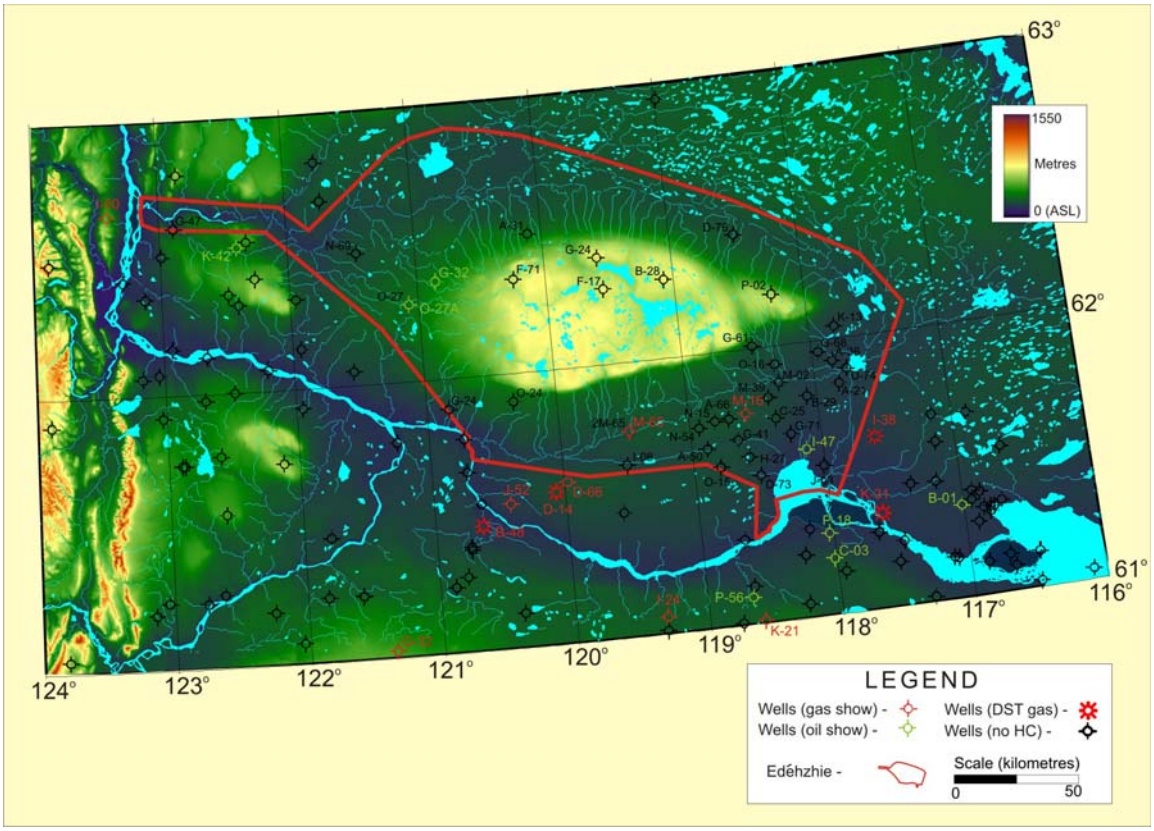

Figure 3. Elevation range of Edéhzhíe area. The elevated area in central Edéhzhíe is Horn Plateau (see Fig. 2).

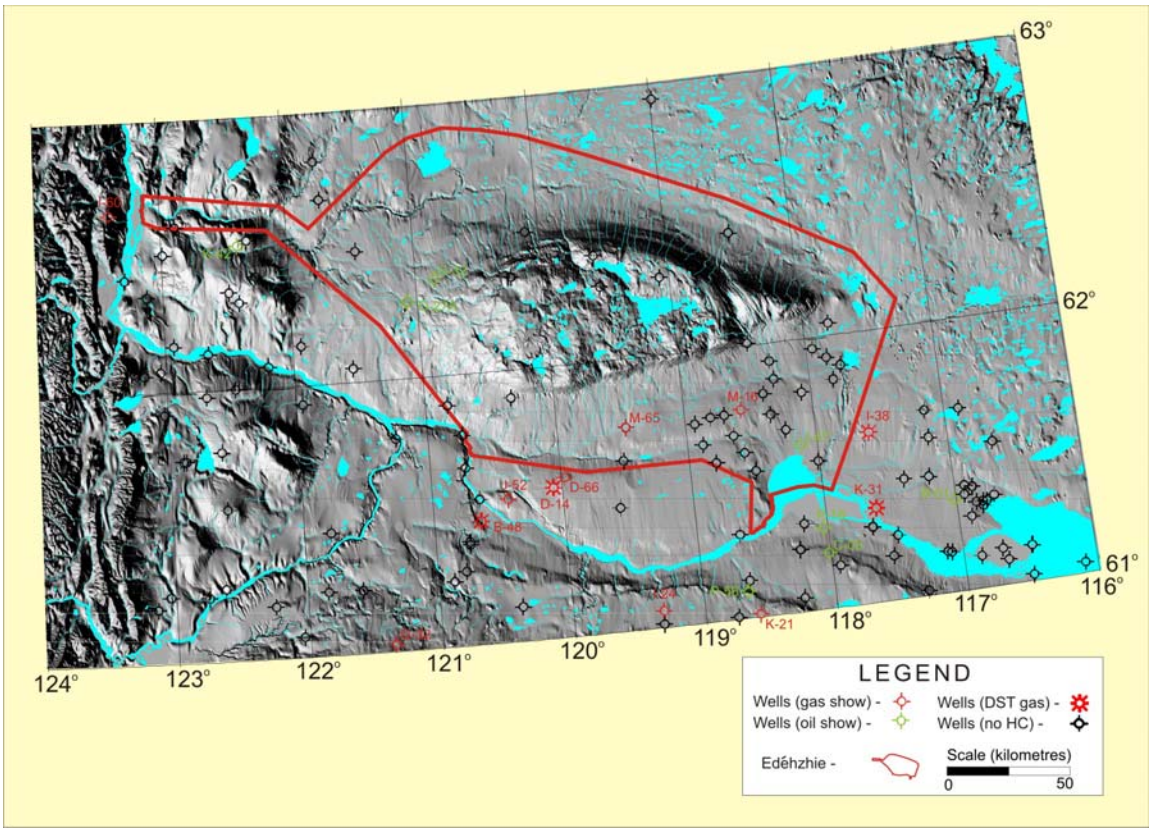

Figure 4. A shaded relief map of the Edéhzhíe region. The Horn Plateau upland dominates the physiography of the region.

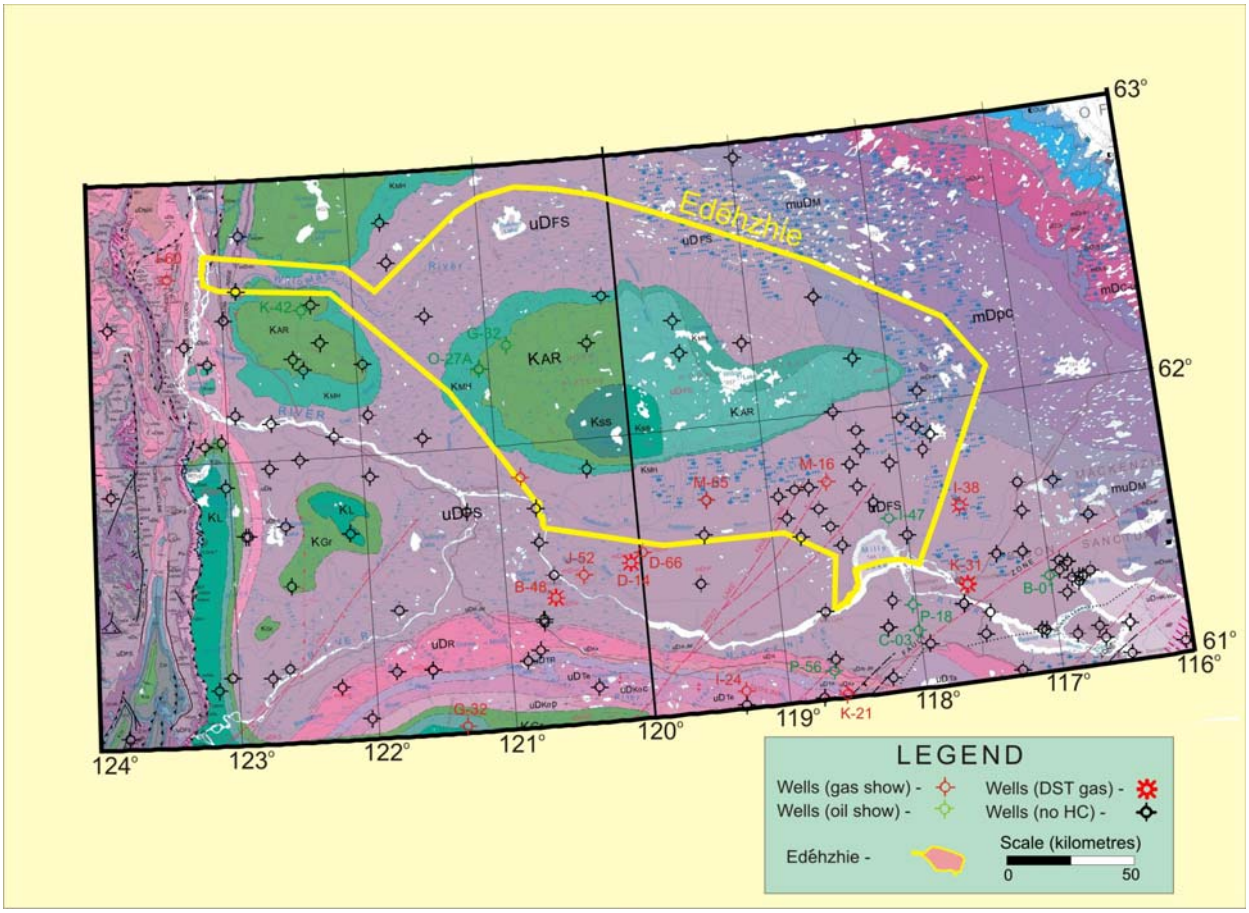

Figure 5. Bedrock geologic map of the Edéhzhíe region (Okulitch, in prep and 2006; see Table 1 for map unit descriptions). Subsurface occurrences Horn Plateau reefs are also indicated. The Horn Plateau upland area (see Fig. 2, 3, 4) is formed of Cretaceous bedrock surrounded by a lowland underlain by Devonian shales of the Fort Simpson Formation (uDFS) and Horn River Group (muDM).

Steeply westward-dipping Proterozoic strata beneath the 'sub-Cambrian' unconformity at the west end of an east-west seismic line (see Figure 6 in Morrow and MacLean (2007)) at Fish Lake (Fig. 2) may represent a portion of the ancestral 'Bulmer Lake Arch' which extended south-southeast from Keller Lake towards Bulmer Lake (Meijer-Drees, 1975; Fig. 2). Southward, Bulmer Arch merges with the broad Tathlina Uplift (Meijer-Drees, 1993) that extended across most of the Northwest Territories immediately south of Edéhzhíe (Fig. 2, 6). Tathlina Uplift remained emergent from Cambrian through to Middle Devonian time (Meijer-Drees, 1975; 1993).

The subsurface depositional limits of lower to mid Paleozoic strata in Edéhzhíe were controlled by Bulmer Lake Arch and Tathlina Uplift. Cambrian deposition across an exposed Precambrian surface was confined to the extreme east and west sides of Bulmer Lake Arch (Fig. 6; Meijer-Drees, 1975; Dixon and Stasiuk, 1998). The regional extent of Bulmer Arch diminished throughout early Paleozoic time so that the depositional limits of the successively younger units of the Cambrian-aged Mount Clark sandstones, Mount Cap shaly siltstones and Saline River red beds, and the Cambro-Ordovician-aged Franklin Mountain dolostones moved progressively eastward and southward until deposition of the Ordovician-Silurian-aged dolostones of the Mount Kindle Formation covered almost the entire former area of the Bulmer Lake Arch across the northern half of Edéhzhíe (Fig. 6, 7; Meijer-Drees, 1975).

Deposition of the Mount Kindle Formation was followed by a brief emergence of the entire Edéhzhíe region along with nearly the entire northern interior plains area to form the regionally extensive 'sub-Devonian' unconformity (Morrow and Geldsetzer, 1988). This was accompanied by deposition of the lower Devonian sandy dolostones of the Tsetso Formation on the east side of Edéhzhíe, and by Arnica dolostones and Fort Norman evaporites, which covered all of the Edéhzhíe area (see Meijer-Drees, 1975).

More open marine conditions in Middle Devonian time was accompanied by deposition of the Landry, Lonely Bay and Nahanni platformal dolostones and limestones, which extended across Edéhzhíe (Fig. 7).

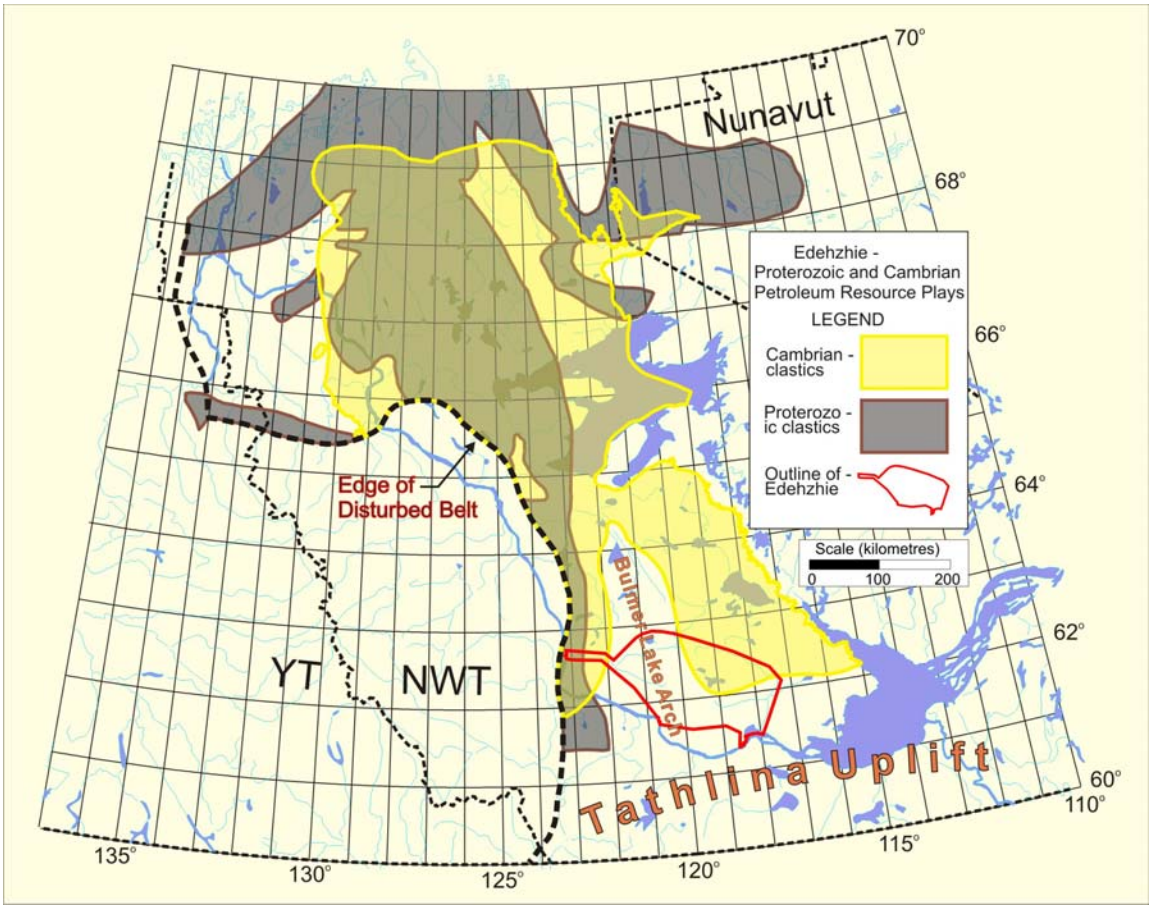

Figure 6. Regional distribution of the Proterozoic and Cambrian clastics play. The Cambrian clastics play is an important contributor to the gas potential of Edéhzhíe. Bulmer Lake Arch confined Cambrian clastic deposits to the extreme western and northeast parts of Edéhzhíe.

Continued sea level rise and sediment influx terminated shallow water carbonate platform deposition which was replaced by anoxic black shale deposition of the Horn River Group north of the Presqu'ile barrier reef complex and across all of Edéhzhíe. Large, occasionally gas-bearing, reef mounds of the Horn Plateau Formation are encased by Horn River shales across a large region north of the Presqu'ile Barrier and occupying the southern half of Edéhzhíe (Fig. 8). Increased influx of clastics from Arctic Canada during the Late Devonian Ellesmerian Orogeny (Gordey et al., 1992) led to deposition of the shaly siltstones of the Fort Simpson Formation above the Horn River Group across the Great Slave Plain and the entire Edéhzhíe area. The Upper Devonian Fort Simpson Formation is the most widespread Paleozoic bedrock unit exposed across Edéhzhíe and surrounds the Cretaceous outlier exposed across Horn Plateau. An economically important diagenetic reservoir facies, the 'Manetoe Dolomite' may have formed during this time. White coarsely crystalline hydrothermal dolomite of the Manetoe Dolomite has replaced large parts of the Landry, Headless and Nahanni formations west of longitude 122° and forms the reservoir for several large producing gas fields west of Fort Liard (Fig. 1; Morrow et al., 1990; Meijer-Drees, 1993).

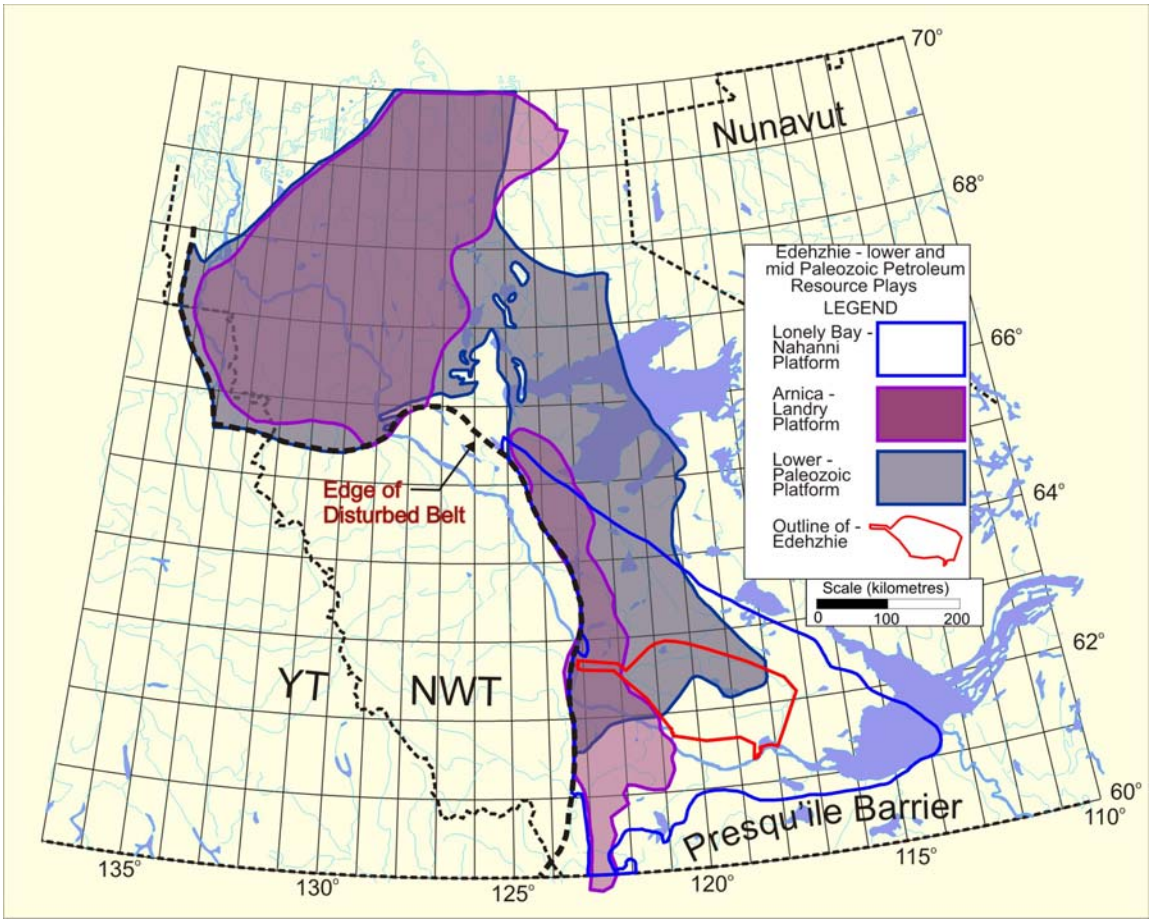

Figure 7. Regional distributions of the Lower Paleozoic platform, the Lonely Bay platform, the Arnica-Landry platform plays in Edéhzhíe. These all contribute to the gas potential of Edéhzhíe. These plays all lie north of all plays that include the typically gas-bearing strata of the Devonian Presqu'ile Barrier reef complex.

Strata younger than Late Devonian were beveled largely during uplift associated with the Jurassic to earliest Cretaceous phase of the Columbian Orogeny (Aitken, 1993) to form the 'sub-Cretaceous' unconformity in the Edéhzhíe area. Above the 'sub-Cretaceous' unconformity, flat-lying Cretaceous strata include variable thicknesses of about 400 metres of shales, siltstones and sandstones of the Arctic Red and Martin House formations and form Horn Plateau (Dixon, 1999). Horn Plateau is capped by a shaly sandstone (Map unit KSS in Fig. 5; see Table 1) within the Arctic Red Formation (Dixon, 1999), but possibly may be equivalent to the Albian Mahoney Lake Formation (Okulitch, 2006). Younger Cretaceous strata were probably eroded across Edéhzhíe during the Tertiary Laramide Orogeny (Aitken, 1993) as well as during later Quaternary glaciation. Quaternary glacial drift mantles most bedrock across Edéhzhíe but the southern slopes of Horn Plateau are covered with colluvium (Rutter et al. 1993). Quaternary deposits nearly 400 metres thick fill a broad valley eroded into Cretaceous strata in the vicinity of the Willow Lake B-28 well (Gal and Lariviere, 2004).

Little is known concerning structural features in the subsurface because of the very small amount of publicly available and low quality, older pre-1980's vintage seismic coverage across the Edéhzhíe area (see Appendix C in Gal and Lariviere, 2004). Gal and Lariviere (2004) noted that fault offsets at the top of the Lonely Bay Formation are seismically imaged northeast of Horn Plateau. They also illustrated numerous northeast and southeast trending air photo lineaments (Figure 7 in Gal and Lariviere 2004) which may be related to subsurface faults. Okulitch (2006) illustrates numerous northeast trending strands of the Trout River fault zone extending across the southern part of Edéhzhíe (Fig. 5).

PERIOD (Epoch, stage)		FORMATION / GROUP [approximate maximum thickness]	LITHOLOGY
Quaternary		Unnamed Quaternary [20 m]	Glacial drift, Colluvium
Unconformity			
Cretaceous	Lower	Mahoney Lake equivalent (subsurface Horn Plateau and KSS – 'rabbitskin sandstone') [50 m]	Sandstone
		Arctic Red (subsurface Horn Plateau and KAR) [300 m]	Shale
		Martin House (subsurface Horn Plateau and KMH) [140 m]	Sandstone, siltstone
Unconformity			
Devonian	Upper	Fort Simpson (subsurface and UDFS) [450 m]	Shale, siltstone, sandstone
		Horn River Group (subsurface; and MUDM; includes Canol equivalent) [110 m]	Black shale
	Middle	Horn Plateau (subsurface; and MDHP) [120 m]	limestone (reef mounds)
		Nahanni/Lonely Bay and Headless; upper Chinchaga and Ebbutt member (subsurface and MDHN) [75 m]	Limestone, Dolostone, shaly limestone
	Lower	Landry; lower Chinchaga (subsurface – only in western extremity of Edéhzhíe; included in Bear Rock on bedrock maps) [20 m]	Limestone
		Arnica (subsurface – only in western extremity of Edéhzhíe) [150 m]	Dolostone
		Fort Norman and Mirage Point including Cold Lake and Johnny Hoe Members (subsurface; equivalent to Bear Rock on surface) [300 m]	Anhydrite, dolostone, Salt
		Tsetso (subsurface – only in western extremity of Edéhzhíe; included in Bear Rock on bedrock maps) [50 m]	Dolostone, siltstone, sandstone
Unconformity			
Ordovician-Silurian		Mount Kindle (subsurface – across northern and central Edéhzhíe only) [200 m]	Dolostone
Unconformity			
Cambrian-Ordovician		Franklin Mountain (subsurface - only in western extremity of Edéhzhíe) [120 m]	Dolostone
Cambrian	Lower-Middle	Saline River (subsurface – only on east and west portions of Edéhzhíe; east and west flanks of Bulmer Lake Arch) [90 m]	Evaporite, red beds
		Unconformity	
		Mount Cap (subsurface – only on extreme east and west portions of Edéhzhíe; east and west flanks of Bulmer Lake Arch) [15 m]	Shale
		Mount Clark (subsurface – only on extreme east and west portions of Edéhzhíe; east and west flanks of Bulmer Lake Arch) [15 m]	Sandstone
Unconformity			
Precambrian	Protero-zoic	Proterozoic units at Mount Cap (Lone Land, Thundercloud and Tsezotene formations (Mackenzie Mountain Supergroup?) [300 m?]	Siliciclastic rocks

Table 1. Stratigraphic units in the Edéhzhíe candidate protected area and their lithologies (see Figure 5 for formational bedrock map designations such as 'UDFS'; thicknesses cited are representative only).

Less than 40 kilometres north of Edéhzhíe, low amplitude structures occur in the subsurface across Great Bear Plain. A broad, 6 kilometre wide, prominent 'pop-up' type of structure occurs in the west-central part of the seismic line north of Fish Lake (Figure 6 in Morrow and MacLean (2007)). This north-south trending structure is dominated by a westward-verging subsurface high-angle thrust, or reverse fault and is developed largely within Paleozoic strata beneath relatively undeformed Cretaceous strata. The large offsets of Devonian strata across the main fault indicate that this structure developed largely before Cretaceous burial (Morrow and MacLean, 2007). Some syn- or post-Cretaceous movement also occurred to cause an offset of the base of the Cretaceous. It seems likely that similar structures may occur in the subsurface of the western part of Edéhzhíe.

West of Great Slave Plain, the Camsell Range of the Franklin Mountains is characterized by a series of linear low ranges and ridges that reach 1600 m in elevation. They are composed of a succession of folded and thrust faulted Paleozoic sedimentary rocks (Fig. 5). Proterozoic siliciclastic rocks are exposed in a small area at Mount Cap, a few kilometers north of the Camsell Range. These strata include the Neoproterozoic Lone Land, the Thundercloud and the Tsezotene formations of the Mackenzie Mountains Supergroup (Aitken et al., 1973). The Franklin Mountains, which form the eastern part of the Cordillera, developed mainly during the post-Paleocene Laramide tectonic event, but earlier, Cretaceous phase(s) of deformation have also been documented (MacLean and Cook, 1999). Also, the significant pre-Cretaceous deformation, as illustrated in Figure 6 of Morrow and MacLean (2007), may have developed during tectonic contraction during the much earlier 'Ellesmerian' orogenic event that affected northwestern Canada in late Paleozoic Devono-Carboniferous time (Richards et al., 1993).

Hydrocarbon Occurrences

Table 2 summarizes exploration drilling results for petroleum resources in the 40 wells drilled within the Edéhzhíe candidate protected area (Fig. 2). 47 drill-stem tests (DSTs) for oil and gas were performed at the wells listed in Table 2. Five of these yielded some natural gas or oil (Table 2). Across a broader region, bounded by latitudes 61° N to 63° N and by 116° W and 124° W longitude, surrounding and including Edéhzhíe, there are 20 wells that show oil and gas in DST's. Most of the gas shows were not measurable on DST and oil shows were either present in extremely small amounts or as traces (Fig. 2: Table 2; see Table 8 of Gal and Lariviere, 2004). Significant gas flows were recorded from the platform carbonates of the Lonely Bay Formation at the Mink Lake I-38 and the NWT Providence #1 K-31 wells and from the Horn Plateau Formation reef buildups at the Trout River D-14 and Trout D-66 and Mink Lake I-38 wells near the eastern and southern borders of Edéhzhíe (Fig. 2).

Exploration for oil and gas was active during the late 60's and early 70's with the last well (CS IOE Jackfish N-69) being drilled in 1973. There is a pronounced well concentration in the southeastern part of Edéhzhíe (Fig. 2, 3, 4). It is likely that the pinnacle-type Horn Plateau reefs were the main intended exploration target along a trend between the type 'Horn Plateau' reef (Vopni and Lerbekmo, 1972) exposed near Fawn Lake and the gas-bearing Horn Plateau reef reservoirs of the Trout River D-14 and Trout D-66 wells about 150 kilometres to the southwest (Fig. 1; see also Gal and Lariviere, 2004)). Cores taken from the Horn Plateau reef exposed at Fawn Lake (Fig. 1) and the underlying Lonely Bay platform carbonates contained oil bleeding from intra-fossil porosity and oil staining (Campbell, 1966; Collins et al., 1969)

Another possible type of target for wells in southeastern Edéhzhíe may have been structural anticlinal-type reservoir traps developed across the Trout Lake fault zone similar to the anticlinal-type Rabbit Lake O-16 gas field (see Morrow, 2007) developed along the Rabbit Lake fault zone south of Edéhzhíe.

These oil and gas shows provide some indication regarding the petroleum prospectivity for this area. There are very few wells throughout most of Edéhzhíe, and, on this basis alone, it is reasonable to assert that the area has not been adequately tested by drilling. Consequently, hydrocarbon shows recorded from petroleum exploration drilling is supportive of some, but low, potential for undiscovered petroleum resources, although at this time exploration risk must be considered as high with consideration of present-day exploration and economic risk factors.

Well name (Grid number)	Unique Well Identifier	Rig Release Date	Total Depth (m)	TD Formation	Status of well (DST Hydrocarbon indications)
HORN R CANDEL ET AL WILLOWLAKE G-47	300G476240122450	7-Apr-71	1310.6	MOUNT KINDLE	Abandoned & Dry
CS IOE JACKFISH N-69	300N696230121150	19-Mar-73	799.5	PROTEROZOIC	Abandoned & Dry
HUSKY ET AL WILLOWLAKE O-27	300O276220121000	27-Jan-70	190.5	FORT SIMPSON	Abandoned & Dry
HUSKY HB ET AL WILLOWLAKE O-27A	302O276220121000	22-Feb-70	890.0	PROTEROZOIC	Abandoned & Dry (DST gas and oil show in Mount Kindle)
HUSKY HB ET AL WILLOW LAKE G-32	300G326230120450	5-Apr-70	836.7	PROTEROZOIC Qtzt	Abandoned & Dry (DST oil show in Mirage Point)
I0E STRONG POINT G-24	300G246200120450	16-Feb-69	757.4	CAMBRIAN	Abandoned & Dry (DST gas show in Lonely Bay)
CHEVRON HARRIS RIVER A-31	300A316240120000	8-Feb-69	735.5	CAMBRIAN	Abandoned & Dry
IMP TRIAD HARRIS RIVER F-71	300F716230120000	8-Apr-60	1010.1	PRECAMBRIAN	Abandoned & Dry
HORN R SOBC ANDEX ALMX GREEN I. O-24	300O246200120150	22-Mar-71	745.8	PROTEROZOIC	Abandoned & Dry
CHEVRON HORNELL LAKE G-24	300G246230119300	3-Mar-69	971.4	SALINE R/ MT CAP	Abandoned & Dry
IMP TRIAD WILLOW LAKE B-28	300B286220119000	10-Mar-60	982.2	PRECAMBRIAN	Abandoned & Dry
JEFF LAKE ET AL HORNELL LAKE F-17	300F176220119300	7-Mar-70	915.9	CHINCHAGA Salt	Junked & Abandoned
GPD NOEL ET AL MILLS WEST M-65	300M656150119150	31-Mar-70	470.9	LONELY BAY	Abandoned & Dry
GPD NOEL ET AL MILLS WEST 2M-65	302M656150119150	8-Apr-70	563.9	CHINCHAGA	Abandoned & Dry
HORN R DECALTA TENN ET AL RABBITSKIN I-08	300I086140119300	31-Mar-71	625.8	PRECAMBRIAN	Abandoned & Dry
HORN R SHELL LEVIS D-76	300D766230118150	19-Feb-71	445.9	PRECAMBRIAN	Abandoned & Dry
IMPERIAL TRIAD DAVIDSON CREEK P-02	300P026220118150	4-Feb-60	834.2	PRECAMBRIAN	Abandoned & Dry
C.S. LAFERTE RIVER G-61	300G616210118150	15-Feb-66	304.8	CHINCHAGA	Abandoned & Dry
C.S. LAFERTE RIVER O-16	300O166200118150	8-Feb-66	290.2	LONELY BAY	Abandoned & Dry
C.S. LAFERTE RIVER M-02	300M026200118150	2-Feb-66	434.0	PRECAMBRIAN	Abandoned & Dry
CS LAFERTE RIVER M-39	300M396150118150	4-Feb-67	434.3	PRECAMBRIAN	Abandoned & Dry
C.S. LAFERTE RIVER B-29	300B296150118000	22-Feb-66	304.8	CHINCHAGA FM	Abandoned & Dry
CS LAFERTE RIVER M-16	300M166150118300	21-Feb-67	512.4	PRECAMBRIAN	Abandoned & Dry (DST gas show in Lonely Bay)
CS LAFERTE RIVER A-66	300A666150118300	8-Apr-67	57.00	PRECAMBRIAN	Abandoned & Dry
CS NOEL LAFERTE RIVER N-15	300N156150118450	3-Mar-70	509.6	PRECAMBRIAN	Abandoned & Dry
CS LAFERTE RIVER N-54	300N546150118450	6-Apr-67	542.5	PRECAMBRIAN	Abandoned & Dry
CS LAFERTE RIVER C-25	300C256150118150	23-Jan-67	481.9	PRECAMBRIAN	Abandoned & Dry
CS LAFERTE RIVER G-71	300G716150118000	23-Jan-67	434.9	PRECAMBRIAN	Abandoned & Dry
CS LAFERTE RIVER G-41	300G416150118300	26-Feb-67	503.2	PRECAMBRIAN	Abandoned & Dry
CS LAFERTE RIVER A-50	300A506140118450	11-Mar-67	569.1	PRECAMBRIAN	Abandoned & Dry
CS LAFERTE RIVER I-47	300I476140118000	9-Feb-67	462.1	PRECAMBRIAN	Abandoned & Dry (DST oil show in Lonely Bay)
CS LAFERTE RIVER H-27	300H276140118300	23-Mar-67	520.6	PRECAMBRIAN	Abandoned & Dry
CS LAFERTE RIVER O-15	300O156140118450	15-Mar-67	594.7	MOUNT CLARK	Abandoned & Dry
CS NOEL LAFERTE RIVER J-03	300J036140118000	12-Mar-70	477.9	PRECAMBRIAN	Abandoned & Dry
CS LAFERTE RIVER D-73	300D736140118150	25-Mar-67	555.3	PRECAMBRIAN	Abandoned & Dry
C.S. LAFERTE RIVER K-13	300K136210117450	6-Apr-66	167.0	CHINCHAGA	Abandoned & Dry
CS LAFERTE RIVER G-68	300G686200117450	30-Mar-66	389.2	PRECAMBRIAN	Abandoned & Dry
C.S. LAFERTE RIVER A-36	300A366200117450	18-Mar-66	203.0	LONELY BAY	Abandoned & Dry
C.S. LAFERTE RIVER D-74	300D746200117300	13-Mar-66	217.0	LONELY BAY	Abandoned & Dry
C.S. LAFERTE RIVER A-21	300A216200117450	8-Mar-66	419.1	PRECAMBRIAN	Abandoned & Dry

Table 2. Summary of wells drilled within the Edéhzhíe candidate protected area and hydrocarbons indicated on well drill stem tests (DST).

Hydrocarbon Prospectivity

The Edéhzhíe candidate protected area is underlain by Proterozoic, Paleozoic and Mesozoic rocks that are prospective for oil and gas. The Canadian Gas Potential Committee (2001, 2005), Gal (2005), Gal and Jones (2003), Gal and Lariviere (2004) and Drummond (2004) have previously defined hydrocarbon plays in the central Mackenzie Valley area that could potentially host oil and/or natural gas. These plays have formed the basis for a set of revised plays, based upon but modified slightly from Hannigan et al. (2006) which are used here to outline the petroleum potential of Edéhzhíe.

Seven of these revised plays occupy portions of Edéhzhíe. These stratigraphically defined plays include the 'Proterozoic clastics', the 'Cambrian clastics', the 'lower Paleozoic platform' the 'Arnica/Landry platform', the 'Lonely Bay/Nahanni/Hume platform', the 'Horn Plateau Reef' and the 'Lower Cretaceous sandstone' plays (Fig. 6, 7, 8). All of these plays are confined to the Interior Plains. Most of these Interior Plains plays have counterparts in the 'disturbed belt' west of Edéhzhíe but are not considered here because Edéhzhíe lies east of the mountainous deformed, belt (see Hannigan et al., 2006).

All of the seven plays that occupy parts of Edéhzhíe have some prospectivity. However, the Proterozoic clastics play, which occupies only a very small area on the extreme western extension Edéhzhíe is considered here to have minimal petroleum prospectivity and is not discussed further.

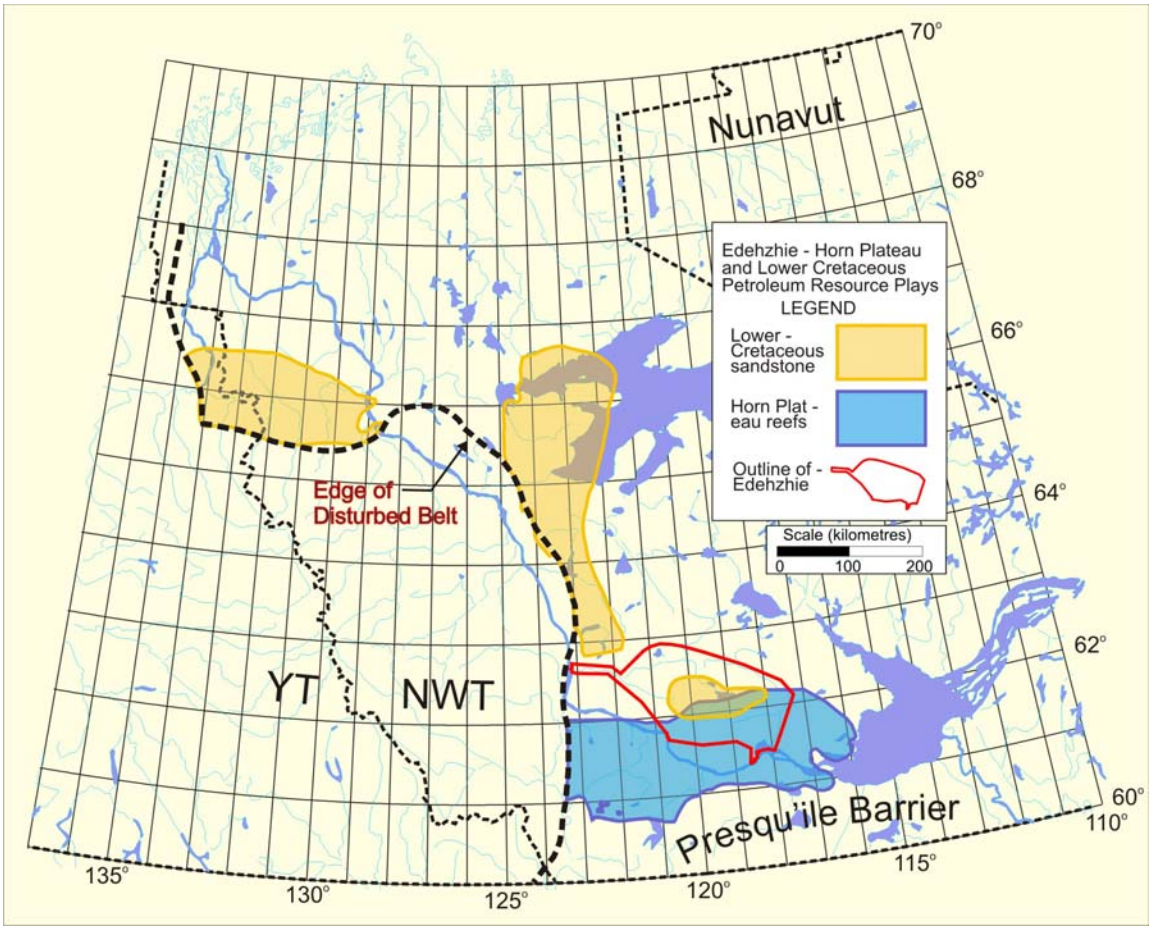

Figure 8. Keg River offshore isolated reef – Horn Plateau and Lower Cretaceous Sandstone plays. Horn Plateau Formation reefs contained within the Keg River offshore isolated reef – Horn Plateau play north of the Devonian Presqu'ile Barrier reef complex.

Cambrian clastics play (established/conceptual[2])

This play (Fig. 6) includes all the prospects and discovered pools in structural and stratigraphic traps in the porous Cambrian quartz sandstone reservoirs of the Mount Clark Formation. This formation has proven to be a good reservoir as it hosts numerous natural gas pools in the Colville Hills area near Colville Lake (Fig 1; Dixon and Stasiuk, 1998). This play is essentially the same as the established/conceptual play of the 'Cambrian Sandstone fairway', as shown on Fig. 3a of the Canadian Gas Potential Committee (2005).

The Mount Clark Formation is present across small parts of northeast and western Edéhzhíe (Fig. 6). Mount Clark penetrations occur only in three wells in the northeast part of Edéhzhíe near Hornell Lake (wells D-76, G-24 and B-18 in Fig. 2). In these wells the Mount Clark sandstone ranges in thickness from 8 to 17 metres. The Mount Clark is much thicker in the Franklin Mountains west of Edéhzhíe and was measured at 218 metres at its type section (Aitken et al., 1973) near Cap Mountain. The western part of the Cambrian clastics play in Edéhzhíe is speculative. No wells have drilled to depths necessary to penetrate of the Mount Clark interval in and around westernmost Edéhzhíe and therefore the presence of the Mount Clark sandstone here is based on extrapolation southward of known Mount Clark north of Greasy Lake (Fig. 2).

Hydrocarbon source beds occur in the overlying Mount Cap (Table 1) shales and siltstones (Dixon and Stasiuk, 1998). These source rocks range from immature to mature in the Colville Hills area where gas discoveries occur. Organic maturity of the Mount Cap probably range from mature on the east side of

[2] An established play has been demonstrated to exist by the discovery of hydrocarbon pools. A conceptual play does not yet have discoveries or reserves, but may exist according to geological analysis.

Edéhzhíe to overmature at the eastern limit of the Camsell Range in the Franklin Mountains based on extrapolation of published organic maturity values for the stratigraphically higher Middle Devonian succession (Stasiuk and Fowler, 2002). In other words, the Mount Cap source beds are presently in the wet to dry gas generation zone of organic maturity. However, nothing is known about the Total Organic Carbon (TOC), or hydrocarbon generation potential, of Mount Cap source beds in the Edéhzhíe area itself.

Structural traps, paleotopographic traps and stratigraphic updip pinch-out types of traps onto Bulmer Lake Arch are possible and have been imaged seismically in the Fish Lake area north of westernmost Edéhzhíe (Morrow and MacLean, 2007). Evaporites of the overlying Saline River Formation provides good reservoir seal. The Canadian Gas Potential Committee (2001, 2005) estimated that about 7.5 trillion cubic feet (Tcf) of natural gas remains to be discovered throughout this play north of 63˚ N latitude. South of 63˚ N latitude Drummond (2004) assigned potential only to a small area that includes the northeast part of Edéhzhíe. Consequently this play can be expected to add some gas potential to Edéhzhíe. Oil potential is not significant in this play because of the level of organic maturity.

Lower Paleozoic platform play (conceptual)

Petroleum reservoirs might occur in porous Ordovician-Silurian carbonate rocks of the Franklin Mountain Formation and, particularly, in the Mount Kindle Formation, which are combined in the lower Paleozoic platform play (Fig. 7). Top seals for this play include anhydrites of the Fort Norman Formation, or possibly younger impermeable intervals. Oil was locally recovered farther north from the fractured Franklin Mountain Formation, where Cretaceous shale provided a source and seal (e.g., East Mackay B-45 well ~20 km south of Tulita). In the Edéhzhíe area, there have been oil and gas shows from wells on the Horn Plateau (Table 2). Both the Franklin Mountain and Mount Kindle formations thicken northwestward from a zero edge depositional limit extending northeastward from Fort Simpson to Willow Lake (Fig. 2). Their combined thickness increases to 450 metres at the western boundary of Edéhzhíe area (Meijer-Drees, 1975).

Although good reservoir facies occur in this play, particularly in the middle fossiliferous and vuggy member of the Mount Kindle Formation, the absence of good organic source rock facies in strata immediately below or above these rocks is a substantial play risk factor. Both structural and stratigraphic traps related to basement faulting and the regional southwestward dip are possible. Also, some updip pinch-out traps may occur along Bulmer Arch. The most favourable scenario for petroleum reservoirs may involve the juxtaposition of Lower Cretaceous source rocks onto strata of this play either erosionally, as at the East Mackay B-45 well, or structurally, by post-early Cretaceous faulting.

The level of organic maturity in this play range from mature on the east side of the Edéhzhíe area to overmature at the eastern limit of the Camsell Range in the Franklin Mountains by extrapolation of the Middle Devonian levels of maturity reported for strata of this area (Stasiuk and Fowler, 2002; see also Feinstein et al., 1988). Consequently this play is more gas prone. Oil accumulations could occur where less mature Cretaceous strata are in direct stratigraphic or structural contact with strata of this play.

Arnica/Landry platform and the Lonely Bay/Nahanni/Hume platform plays (conceptual)

Vuggy dolostone of the Arnica Formation and solution breccia of the Bear Rock Formation are potential oil and gas bearing horizons. This stratigraphic interval yielded both oil and gas at the Summit Creek B-44 well in a recent discovery approximately 70 km south of Tulita (Unocal Corporation, 2005: Fig. 1). Although few details concerning this discovery have been published, it is likely that the Bear Rock and Arnica to Hume succession forms the petroleum reservoir and that the overlying Horn River or ‘Canol’ dark shales act as the reservoir seal and as the organic source rock for hydrocarbons.

In general, the Landry, Nahanni and Hume formations are non-porous limestones (see Gal and Jones, 2003) that may act as seals for more porous Arnica dolostones. It is possible that structurally induced fracturing of the Hume Formation provided downward egress for petroleum generated at Summit Creek into underlying Arnica/Bear Rock reservoirs. It is possible that similar situations occur in the subsurface of the Mackenzie Plain portion of the Edéhzhíe area where strata of these plays are involved in regional folding beneath Upper Devonian shales (e.g. Fort Simpson Formation). It is even possible that faulted folds may also be favourable for ‘Summit Creek’ types of reservoirs.

Another possibility would involve pre-Cretaceous erosional truncation of late Paleozoic subsurface folds, such as displayed in Figure 6 of Morrow and MacLean (2007) in Great Bear Plain, so that basal Cretaceous source rock shales directly overly Devonian platform carbonates. Structural juxtaposition of Cretaceous source rocks with Devonian platform carbonates is also possible. However, the relatively low maturity of Cretaceous source rocks across Great Bear Plain (Stasiuk and Fowler, 2002; see also Feinstein et al., 1988) indicates that reservoirs of this type would contain heavy oil similar to that in the East Mackay B-45 well.

Another, less likely possibility, concerns the existence of the Manetoe Dolomite in the western part of the Edéhzhíe area. Hydrothermal dolomite of the Manetoe Dolomite has recrystallized Landry Formation beneath the Headless shaly limestone in Horn R Candel et al Willowlake G-47 well near the western boundary of Edéhzhíe. This greatly improves the reservoir quality of these strata. However, unless Manetoe Dolomite can be found above the base of the Hume, or Headless/Nahanni it is unlikely that the mere presence of this diagenetic facies improves the risk of finding gas fields similar to those in the Liard Basin. In that area, massive dolomitization of the Manetoe Dolomite extends to the top of the Middle Devonian carbonates, which allowed downward egress of petroleum generated from overlying organic-rich black shales of the Horn River Group into the entire Nahanni to Arnica stratigraphic interval (Morrow et al., 1990).

The more porous lower member of the Lonely Bay Formation, the Dolostone member (Meijer-Drees, 1993) is also potential petroleum reservoir facies for petroleum sourced from the overlying Horn River shales (Gal and Lariviere, 2004). Horn River shales range in degree of organic maturity from mature, or in the oil generation zone, in eastern Edéhzhíe to overmature, or in the gas generation zone, in western Edéhzhíe (Stasiuk and Fowler, 2002). The gas shows in the Lonely Bay in the Mink Lake I-38 and NWT Province #1 K-31 wells (Table 2) provide support for the existence of undiscovered petroleum in the Dolostone member. However, the separation of the Dolostone member from the overlying Horn River shales by the rather impermeable and low porosity upper Limestone member of the Lonely Bay Formation is a risk factor for this reservoir type.

Keg River offshore isolated reef – Horn Plateau play (conceptual)

As previously discussed, this play motivated early exploration across southeastern Edéhzhíe following the 1969 and 1970 gas discoveries in Horn Plateau reefs at the Cdn Sup KMG Jean Marie B-48 and at the Gulf et al Trout River D-14 wells, and the 1971 gas show at the Horn R Decalta et al Trout D-66 well a few kilometers south of Edéhzhíe and the gas discovery at the Horn River Placid IOE Mink Lake I-38 close to the east side of Edéhzhíe (Fig. 2). This play extends northward from the Presqu'ile Barrier and occupies the southeastern third of the Edéhzhíe area (Fig. 8). Potential reservoirs are isolated reef mound buildups extending upwards from the upper contact of the Lonely Bay platform, but also may include reef-slope mounds that may be completely encased in shales of the Horn River Group. The organic-rich, black Horn River shales are the probable source rocks for petroleum in the stratigraphic reef traps of this play. The northward limit of this play was defined by Gal and Jones (2003) as including all pools and prospects in isolated reefs and bioherms located basinward, or outboard, from the Presqu'ile Barrier edge (Fig. 8). The eastern boundary is the subcrop/outcrop edge at the boundary with the Canadian Shield. Another criterion for the northern play boundary is the northward passage from relatively thick more than 100 metre-thick Horn River Group slope deposited shales to a thinner basinal shale succession less than 50 metres thick (Williams, 1985). Prospectivity in this play is moderate for gas and low for oil.

Lower Cretaceous Sandstone play (conceptual)

At the 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 that produced natural gas from two zones (Husky Energy, 2006).

Siltstones and sandstones of the Martin House Formation at the base of the Cretaceous on Horn Plateau is a possible Cretaceous reservoir rock in the Edéhzhíe area. This unit becomes more shaly south of Great Bear Plain and is perhaps less prospective in the Edéhzhíe area than Martin House strata farther north (Dixon, 1999). This unit ranges from about 41 metres to 68 metres thick in the four wells where penetrated in this area (F-71, B-28, P-02, and G-24; Fig. 2). Extrapolation of the data of Stasiuk et al. (2002) indicates that Cretaceous organic-rich source rocks, such as the overlying Arctic Red Formation

shales, are probably immature in the Edéhzhíe area. Farther west, in the disturbed belt, Cretaceous source rocks are in the zone of organic maturity for oil generation (Stasiuk et al., 2002). Conceivably, eastward updip oil and gas migration could charge Columbian- to Laramide-aged structural, or stratigraphic, traps beneath Horn Plateau. These traps could involve stratigraphic pinchouts against the sub-Cretaceous unconformity along with sand to shale facies transitions. Also, oil generated from source rocks in the Fort Simpson Formation beneath Horn Plateau could have migrated upwards into overlying basal Cretaceous sands.

This play is high risk because of the probability of breaching and meteoric groundwater invasion of the shallow potential reservoirs of this play that are confined to the isolated region of Horn Plateau (Fig. 8).

Qualitative and Quantitative estimates of Hydrocarbon Potential

Gal and Lariviere (2004) assigned a "Moderate" petroleum potential rating to almost the entire Edéhzhíe area apart from the small westernmost extension of Edéhzhíe along the Willowlake River which they assigned a "High" rating (Figure 26 in Gal and Lariviere, 2004). This qualitative assessment was based primarily upon a cumulative weighting based upon the number of overlapping conceptual plays within Edéhzhíe none of which can be rated individually as having a particularly high potential. However, the results of subsequent, more quantitative studies (Canadian Gas Potential Committee, 2005; and Drummond, 2004) indicate that ratings of "Moderate" to "High" potential for the Edéhzhíe area may be optimistic.

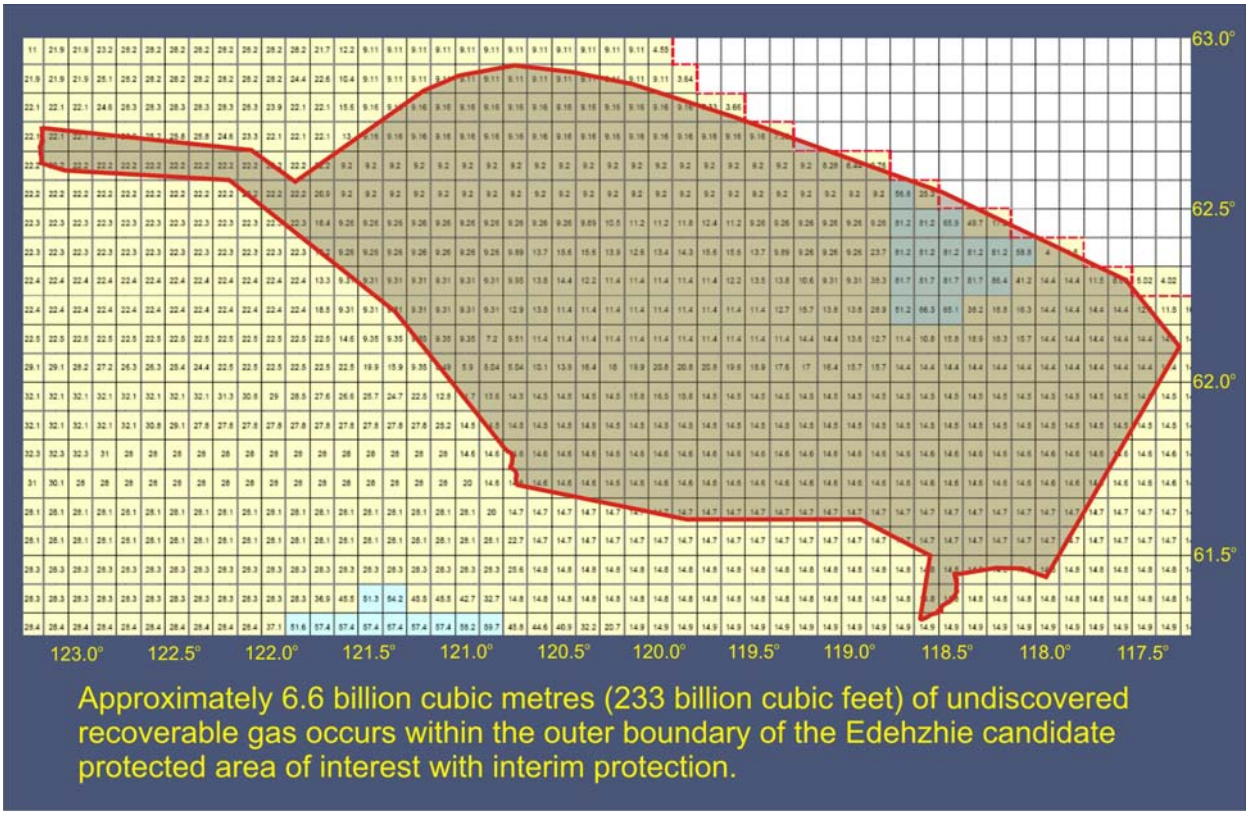

Figure 9. The overall potential for undiscovered recoverable gas in the Edéhzhíe candidate protected area is about 0.23 trillion cubic feet subequally apportioned between five plays (adapted from Figure 9 in Drummond, 2004). Note the small region of northeast Edéhzhíe that displays a block of quarter grid areas with higher than the average potential of quarter grid areas across the remainder of Edéhzhíe. This is due to the addition of the relatively high potential Cambrian clastic play that is largely confined to this block of quarter grids.

Of all plays occupying portions of Edéhzhíe, the "Cambrian clastics" play has the highest potential overall. However, because of the small area occupied by this play in Edéhzhíe, Drummond (2004) assigned only 1.28 billion cubic metres (45 billion cubic feet) of gas to this play for the Edéhzhíe area.

For the entire Edéhzhíe candidate protected area, based on Drummond (2004), a total undiscovered petroleum resource potential of about 6.6 billion cubic metres (or 233 billion cubic feet) of natural gas can be assigned to the Edéhzhíe area (Fig. 9). In his assessment, the total potential for undiscovered natural gas in Edéhzhíe is subequally divided between the potentials of the Keg River offshore isolated reef – Horn Plateau play, the Cambrian Clastics play, the Lonely Bay/Nahanni Platform play, the Arnica/Landry Platform play, and the Lower Paleozoic platform play listed in order of their relative contribution to total gas potential.

Oil potential for the Edéhzhíe area, based on Drummond (2004), can be estimated to be about 80 thousand cubic metres, or half a million barrels of oil in the portion of the Lower Cretaceous sandstone play at Horn Plateau (Fig. 10). No other play was considered by Drummond (2004) to contribute measurably to the oil potential of Edéhzhíe. This is because of the strong likelihood that gas generated from downdip Paleozoic source rocks migrated updip by buoyancy northeast across Edéhzhíe and probably actively displaced oil generated and trapped locally in lower Paleozoic Edéhzhíe reservoirs.

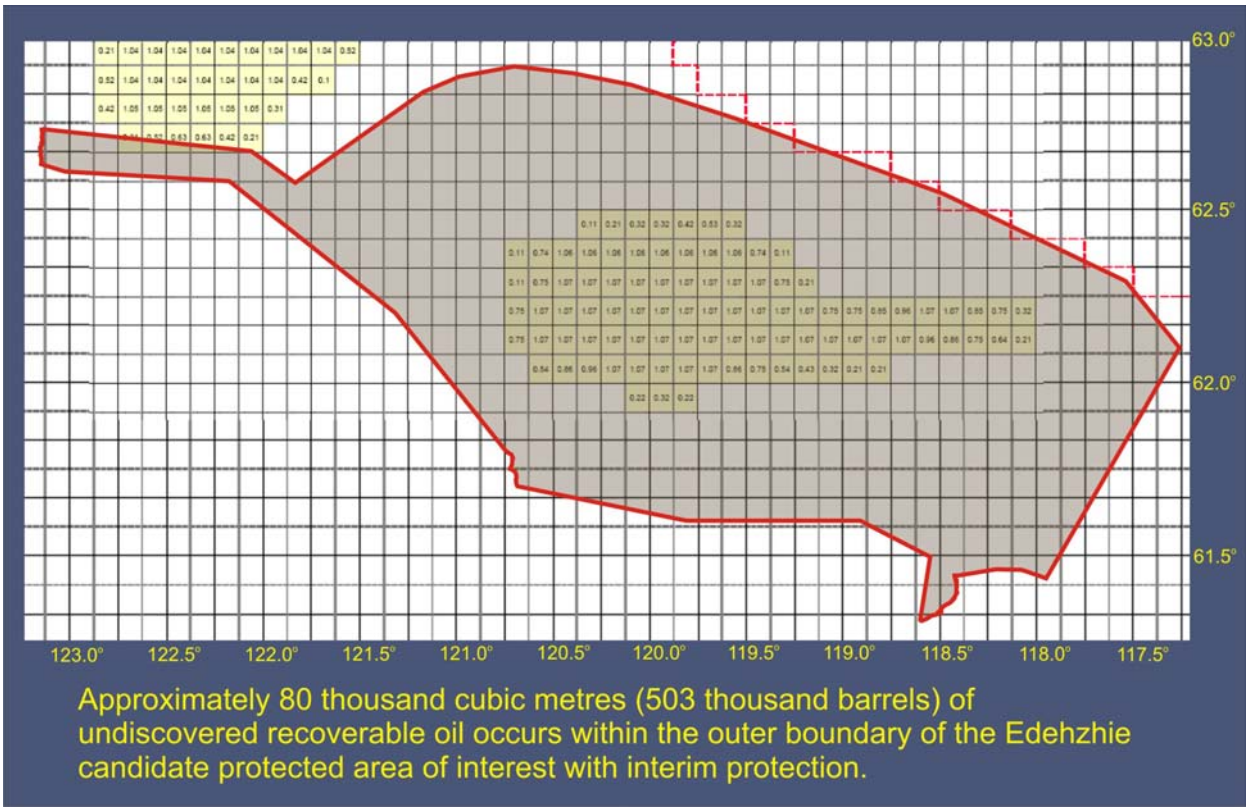

Figure 10. The potential for undiscovered recoverable oil in the Edéhzhíe candidate protected area is about half a million barrels. This relatively small amount is contributed only by one play, the Lower Cretaceous sandstone play beneath Horn Plateau. Oil in the underlying Devonian is present and was generated in large volumes but downdip gas generation in post-Paleozoic time has 'swept' Devonian oils generated in the Edéhzhíe area eastward by buoyant displacement.

Conclusions

In summary, the petroleum potential of the Edéhzhíe candidate protected area is rather low. This low potential is largely the consequence of the Edéhzhíe area lying outside of the areas of the high potential plays that lie south of the northern limit of the Devonian Presqu'ile Barrier (Fig. 7, 8) and almost entirely south of the area of the high potential Cambrian Clastics play (Fig. 6). The lower potential Keg River offshore isolated reef – Horn Plateau play is the most significant contributor to the ultimate petroleum resource potential of Edéhzhíe and several other plays (the Cambrian Clastics play, the Lonely Bay/Nahanni Platform play, the Arnica/Landry Platform play, and the Lower Paleozoic platform play) are also significant contributors. The available evidence and previously published assessments suggest an

ultimate potential of about 0.23 Trillion cubic feet (Tcf) of natural gas within the Edéhzhíe candidate protected area.

The recently discovered 'Summit Creek' type reservoirs could be encountered in subsurface structural culminations in Edéhzhíe, but this is unlikely. Future seismic studies across Edéhzhíe are needed to document, or to disprove this possibility.

Oil prospectivity is low, only about 0.5 million barrels and is confined to the basal Cretaceous sandstones beneath Horn Plateau.

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References

Aitken, J.D. 1993: Tectonic evolution and basin history; Chapter 5 in Sedimentary Cover of the Craton an Canada, D.F. Stott and J.D. Aitken (ed.); Geological survey of Canada, Geology of Canada, no. 5, p. 483-502 (also geological Society of America, The Geology of North America, v. D-1).

Aitken, J.D., Macqueen, R.W., and Usher, J.L. 1973: Reconnaissance Studies of Proterozoic and Cambrian Stratigraphy, Lower Mackenzie River Area (Operation Norman), District of Mackenzie; Geological Survey of Canada, Geological Survey of Canada, Paper 73-9, 178p.

Bostock, H.S. 1970: Physiographic Subdivisions of Canada; in Geology and Economic minerals of Canada, R.J.W. Douglas (ed.); Geological Survey of Canada, economic Geology Report, no. 1, p. 10-30.

Campbell, D.L. 1966: Progress Report on Belfoi P. & N. G. Permits Nos. 4541-4552 (inc.) 4698, and 4699, Horn River area, NWT, Report for Western Decalta Petroleum Ltd.; National Energy Board Open File Report 19-14-4-24.

Canadian Gas Potential Committee 2001: Natural Gas Potential in Canada, 2001; CDROM.

Canadian Gas Potential Committee 2005: Natural Gas Potential in Canada, 2005; CDROM.

Collins, G.M., Klipfel, C.I., and Wallace, F.K. 1969: Evaluation from Geophysical and Geological Data of the Horn Plateau Reef Project, Northwest Territories, Canada; Report for Operation Geoquest by Pallister and Associates and V. Zay Smith Associates Ltd.; National Energy Board Open File Report no. 693-6-4-3.

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

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.

Drummond, K.J. 2004: Oil and Gas resources and Field Size Distribution of the Deh Cho Territory (prepared for Deh Cho Land Use Planning Committee); Drummond Consulting, 148p.

Feinstein, S., Brooks, P.W., Gentzis, T., Goodarzi, F., Snowdon, 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 Jones, A.L. 2003: Evaluation of Oil and Gas Potential in the Deh Cho Territory; CS Lord Northern Geoscience Centre, Yellowknife, NWT Open File 2003-03, 88p.

Gal, L.P., and Lariviere, J.M. 2004: Edehzhie Candidate Protected Area Non-renewable Resource Assessment (Phase I), Northwest Territories, Canada, NTS 085E-F-K-L and 095H-I-J; CS Lord Northern Geoscience Centre, Yellowknife, NWT Open File 2004-01, 125p.

Gordey, S.P., Geldsetzer, H.H.J., Morrow, D.W., Bamber, E.W., Henderson, C.M., Richards, B.C., McGugan, A., Gibson, D.W., and Poulton, T.P. 1992: Part A Ancestral North America; in Upper Devonian to Middle Jurassic assemblages, Chapter 8 of Geology of the Cordilleran Orogen in Canada, H. Gabrielse and C.J. Yorath (eds.); Geological Survey of Canada, Geology of Canada, no. 4, p. 219-327 (also Geological Society of America, The Geology of North America, v. G-2).

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 (CDRom).

Husky Energy 2006: Husky Energy news release ("Husky Energy Announces discovery in Northwest Territories" at Stewart Creek D-57 well; Husky Energy news release, May 17, 2006.

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.

Meijer-Drees, N.C. 1975: Geology of the Lower Paleozoic formations in the Subsurface of the Fort Simpson area, District of Mackenzie, Northwest Territories; Geological Survery of Canada, Paper 74-40, 65p.

Meijer-Drees, N.C. 1993: The Devonian Succession in the Subsurface of the Great Slave and Great Bear Plains, Northwest Territories; Geological Survey of Canada, Bulletin 393, 222p.

Morrow, D.W. and MacLean, B.C. 2007: Pehdzeh Ki Ndeh Area of Interest – Hydrocarbon Assessment Summary Report; Geological Survey of Canada, Open File 5555, CD-Rom.

Morrow, D.W. 2007: K'ágee Tu Area of Interest – Hydrocarbon Assessment Summary Report; Geological Survey of Canada, Open File 5556, CD-Rom.

Morrow, D.W. and Geldsetzer, H.H.J. 1988: Devonian of the Eastern Canadian Cordillera; in Second International Symposium on the Devonian System, McMillan, N.J., Embry, A.F. and D.J. Glass (eds.); Canadian Society of Petroleum Geologists, Memoir 14, v. 1, p. 85 121.

Morrow, D.W., Cumming, G.L., and Aulstead, K.L. 1990: The Gas-Bearing Devonian Manetoe Facies, Yukon and Northwest Territories; Geological Survey of Canada, Bulletin 400, 40p.

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.

Okulitch, A.V. (compiler). in prep: Bedrock Geology, Redstone River, Yukon Territory, Northwest Territories; Geological Survey of Canada, Map NP-9/10-G, scale 1:1000000 (National Earth Sciences Series, Geological Atlas); Geological Survey of Canada, Open File.

Okulitch, A.V. (compiler). 2006: Phanerozoic Bedrock Geology, Slave River, District of Mackenzie, Northwest Territories; Geological Survey of Canada, Map NP-11/12-G, scale 1:1000000 (National Earth Sciences Series, Geological Atlas).

Richards, B.C., Bamber, E.W., Higgins, A.C., and Utting, J. 1993: Carboniferous, Subchapter 4E; in, Sedimentary Cover of the Craton in Canada, D.F. Stott and J.D. Aitken (eds.); Geological Survey of Canada, Geology of Canada, no. 5, p. 202-271.

Rutter, N W; Hawes, R J., and Catto, N R. 1993: Surficial Geology, Southern Mackenzie River Valley, District of Mackenzie, Northwest Territories; Geological Survey of Canada, "A" Series Map 1693A.

Stasiuk, L.D. and Fowler, M.G. 2002: Thermal maturity evaluation (vitrinite and vitrinite reflectance equivalent) of Middle Devonian, Upper Devonian and Mississipian 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).

Unocal Corporation 2005: Unocal press release (“Unocal announces discovery in Northwest Territories, Canada” at Summit Creek B-44 well) March 30, 2005; Unocal Press Release Archives.

Vopni, L.K. and Lerbekno, J.F. 1972: The Horn Plateau Formation: a Middle Devonian Coral Reef, N.W.t.; Bulletin of Canadian Petroleum Geology, v. 20, p. 498-548.

Williams, G. K. 1985: Middle Devonian Facies Belts; Geological Survey of Canada, Open File 1353. (map and 9 page text report).