NWT Open File 2008-06

Ka´a´gee Tu Area of Interest
Phase I Non-renewable Resource Assessment - Minerals, Northwest Territories, Parts of NTS 85 C, 85 D, 85 E and 85 F

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SUMMARY

This document presents a Phase I non-renewable resource assessment (NRA) of the Ka´a´gee Tu area of interest completed as part of the Northwest Territories Protected Area Strategy (PAS). Phase I studies compile historical information, provide a preliminary assessment and make recommendations for further Phase II studies. The results from NRA studies are intended to allow land use planners to make informed decisions in accordance with Government of Canada policy.

Ka´a´gee Tu covers the area surrounding Tathlina and Kakisa Lakes between the Cameron Hills and Great Slave Lake. The study area lies in the Deh Cho region and covers about 8,700 km^2 in NTS areas 85 C and 85 D 85 E and 85 F. Kakisa is the only community in the region and the northern portion of the study area is crossed by the Mackenzie Highway.

The study area lies in the Mackenzie and Slave Lowlands Mid-Boreal Ecoregion, an area dominated by fens and peat plateaus intermixed with patches of mixed wood and coniferous forest. Elevation increases towards the south and rises from about 150 m near Great Slave Lake to about 600 m near the crest of the Cameron Hills.

Ka´a´gee Tu is located in the Interior Platform geological province that is composed of sedimentary cover rocks that overlie Precambrian basement. Cover rocks of the Western Canada Sedimentary Basin (WCSB) form a wedge that increases in thickness towards the southwest. The WCSB contains two major sedimentary successions; an older succession of Proterozoic to mid-Jurassic marine sediments deposited on a passive continental margin and a younger succession of Late Jurassic to Tertiary rocks derived from the erosion of the evolving Cordilleran Orogen to the west.

The study area lies west of the Pine Point area, a world-class lead-zinc camp that produced 64.3 Mt at about 3% Pb and 7% Zn. Unlike many frontier areas of the NWT, the study area has supporting infrastructure including the Mackenzie Highway and a railroad lying to the east at Hay River.

Hydrothermal dolomite is locally developed in Middle Devonian rocks of the Presqu'ile barrier complex adjacent to major northeast-trending fault zones (e.g. between the Tathlina fault zone and the Cameron Hills structure in the northeastern portion of the study area). Host lithologies and alteration are favourable for the development of Mississippi Valley-type mineralization, although widely-spaced exploration drilling has only revealed small amounts of Pb-Zn mineralization. Ka´a´gee Tu has a moderate to high potential for lead-zinc deposits, with the economic importance of the region decreasing to the southwest with the increasing depth of favourable stratigraphy. The near-future prospects for locating subsurface resources are likely low, although future improvements in exploration technology could upgrade the importance of this area.

Basement rocks in the eastern study area are favourable for kimberlite intrusions, although no public data is available to further refine the mineral potential assessment. The diamond potential of the area is rated as low to moderate with a high level of uncertainty. Phase II studies should undertake surficial mapping and sampling required for a granular resource assessment and an evaluation of diamond potential.

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INTRODUCTION

Background

The study area (Figure 1) lies in the traditional land use area of the Ka΄a΄gee Tu First Nation and covers much of the Kakisa River watershed. The area was identified as a conservation zone in the Draft Deh Cho Land Use Plan (Zone 14 - Kakisa and Tathlina Watershed; Deh Cho Land Use Planning Committee, 2006), and withdrawal of subsurface mineral rights until October of 2008 has been undertaken under the Deh Cho Interim Measures Agreement.

Terms of Reference

The Northwest Territories Protected Area Strategy (PAS) was established in 1999 to provide a community-driven framework for the creation of protected areas. This framework consists of an eight step process for identifying, evaluating and formally designating protected areas (Northwest Territories Protected Area Strategy Advisory Committee, 1999). Ecological and non-renewable resource assessments (NRA) are completed at step five during the evaluation of proposed candidate areas. Mineral resource assessments also support the Government of Canada's Minerals and Metals Policy (1996) that states the mineral potential of an area should be fully considered before the decision to create a protected area on federal lands is taken.

A petroleum resource assessment of the study area has been previously completed (Morrow, 2007). This current study presents a Phase I mineral assessment based upon a desktop compilation of existing geological information and an evaluation of potential based on expert opinion and current ore deposit models. It outlines a ranking system for mineral potential and applies this system to the study area. It also identifies gaps in geoscience information and makes recommendations for Phase II studies.

As resource assessments are based upon existing geoscience information, these assessments must be updated as new information becomes available or as economic conditions change making resource exploitation feasible. This NRA is a planning tool that represents a best estimate of potential at a fixed point in time. As mineral resources are generally hidden in the subsurface, they cannot be quantified with absolute certainty.

Mineral Potential Ranking System

The mineral potential ranking system used in this study considers mineral deposit models within the context of the known geological setting and is based upon criteria developed for the Mineral and Energy Resource Assessment process used by the Geological Survey of Canada (Scoates et al., 1986). This ranking system has been used in previous mineral assessments in NWT including the Edehzhie Candidate Protected Area (Gal and Lariviere, 2004) that lies about 150 km northwest of the current study area. As this rating system is partially dependant on the number of historical showings, it may underestimate the true potential of areas at the beginning of an exploration cycle or exploration that relies on new models or proprietary ideas that are not widely known.

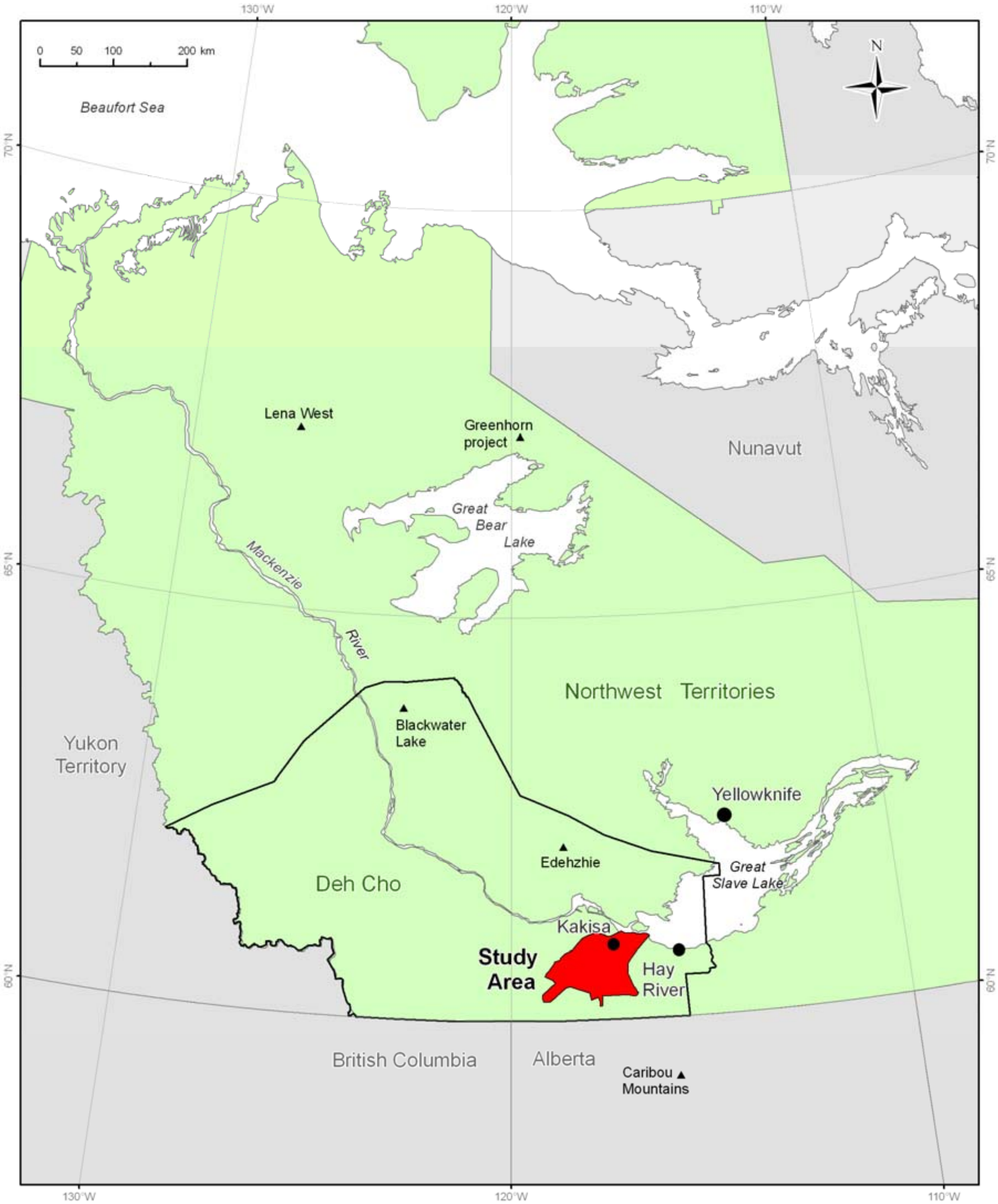

Figure 1. *Regional location of study area. Other areas mentioned in the report (i.e. Lena West, Greenhorn project, Blackwater Lake, Edehzhie and Caribou Mountains) are also indicated.*

Location, Area and Access

Ka´a´gee Tu covers the area surrounding Tathlina and Kakisa Lakes between the Cameron Hills and Great Slave Lake. The study area lies in the Deh Cho region and encompasses about 8,700 km^2 in NTS areas 85 C and 85 D 85 E and 85 F. Kakisa is the only community in the region and the northern portion of the study area is crossed by the Mackenzie Highway.

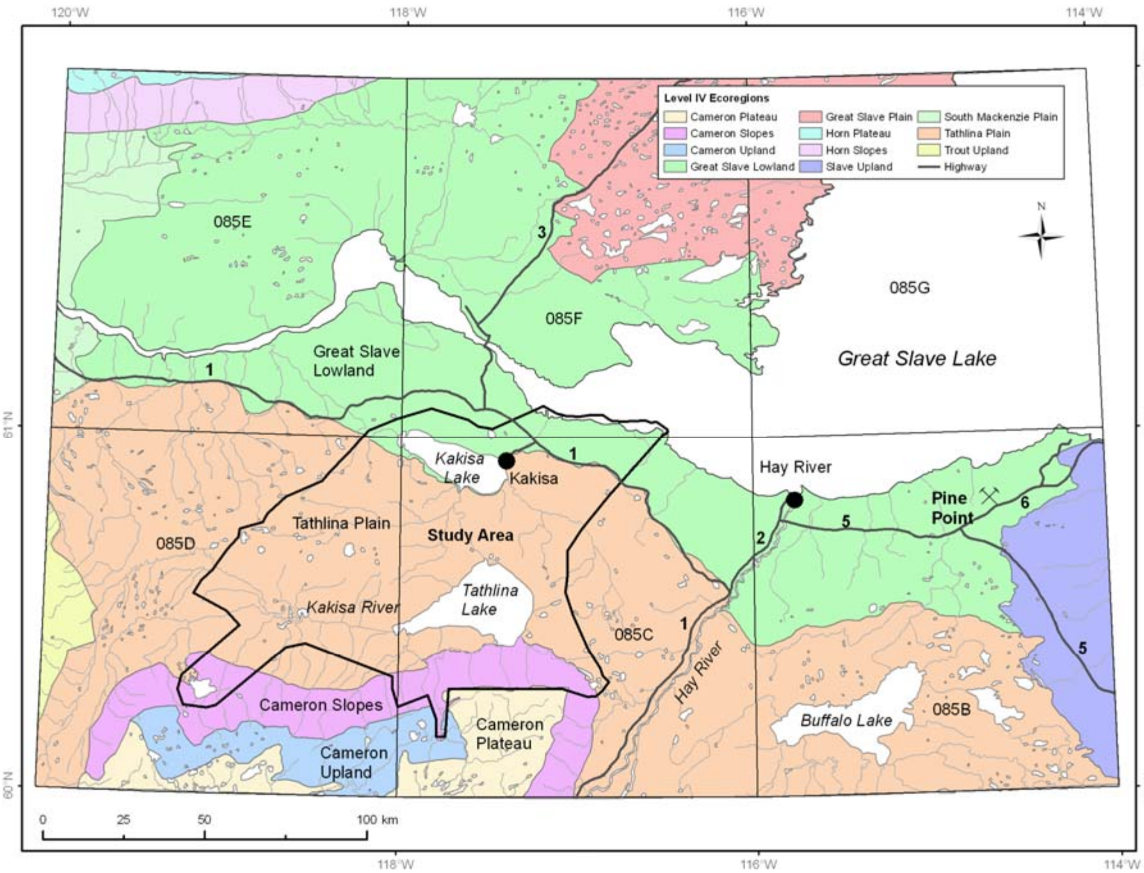

Figure 2. *Ka΄a΄gee Tu showing NTS areas and Level IV Ecoregions from Ecosystem Classification Group (2007).*

Physiography, Climate and Vegetation

The study area lies in the Great Slave Plain physiographic region (Bostock, 1970), a lowland area that is underlain by gently dipping Phanerozoic sedimentary rocks. Bedrock is commonly concealed beneath glacial deposits. The region lies in the zone of sporadic discontinuous permafrost (Heginbottom, 2000). Elevation increases towards the south and rises from about 150 m near Great Slave Lake to about 600 m near the crest of the Cameron Hills.

The ecological classification of Taiga Plains in the Northwest Territories (NWT) has recently been revised by the Ecosystem Classification Group (2007). The table below outlines the updated ecological regions in the study area.

Table 1. Ecological stratification

Physiographic Region	Ecological Stratification Working Group (1995)	Ecosystem Classification Group (2007)	
		Level III Regions	Level IV Regions
Great Slave Plain	Hay River Lowlands Ecological Region	Mackenzie and Slave Lowlands Mid-Boreal Ecoregion	Great Slave Lowland MB Ecoregion
			Tathlina Plain MB Ecoregion
			Cameron Slopes MB Ecoregion

The area of interest belongs to the Mackenzie and Slave Lowlands Level III Ecoregion that has a mid-boreal climate. This area experiences the mildest conditions in the Northwest Territories and has a mean annual temperature between -2.0 and -5.5 ^{o}C. Within the study area, this Level III Ecoregion is further subdivided into three Level IV regions listed in Table 2.

The Great Slave Lowland is a nearly flat wet-land dominated area composed of scattered patches of mixed-wood and jackpine forests intermixed with fens and peat plateaus. This region is separated from the Tathlina Plain to the south by a low escarpment of Devonian limestone. The mean elevation of the Tathlina Plain is about 125 m higher than the Great Slave Lowland but is composed of similar vegetation types. The landscape is dominated by peat plateaus and fens. Less common are gently undulating lacustrine and till deposits that form upland areas supporting patches of jackpine and mixed-wood stands. The Cameron Slopes separate the low-elevation Tathlina Plain from the higher-elevation Cameron Plateau. This region is gently to moderately sloping and contains numerous streams that drain from the Cameron Hills. Wet areas containing fens are locally found at the base of the Cameron Hills and vegetation on slopes includes pure or mixed stands of trembling aspen, balsam popular and white spruce.

Previous Work

The geological database has been expanded by both government and exploration efforts. Primary data sources and data gaps are outlined in the table below.

Table 2. Previous work

Subject	Source
Bedrock geology	Douglas and Norris (1974) 1;500,000 Okulitch and Fallas (2007) 1:1,000,00
Surficial geology – national scale	Fulton (1995) 1:5,000,000
Surficial geology - (NTS areas 85 D and 85E only)	Rutter et al. (1993) 1:500,000
Surficial geology and geomorphology (NTS areas 85 D and 85E only)	Rutter and Boydell (1979) 1:125,000 Rutter et al. (1980) 1:125,000
Aeromagnetic data at 200 m grid spacing; residual total magnetic field and first vertical derivative of magnetic anomalies	Canadian Aeromagnetic Data Base (2005)
Gravity data at 2 km grid spacing; observed gravity, gravity anomaly, free-air anomaly, Bouger anomaly, isostatic residual gravity anomalies, horizontal gradient of gravity anomalies and first vertical derivative of gravity anomalies	Canadian Geodetic Information System (2005)
National radiometric data	not available for study area
National geochemical reconnaissance data	not available for study area
Lithoprobe seismic study of basement features	Interpretation of SNORCLE Line 1 data provided in Lynn et al. (2005)
Compilation of structural elements of northern Alberta (note; compilation also extends into the southern NWT)	Pană et al. (2001) Pană and Waters (2003)
Presqu'ile dolomite in the Great Slave Plain	Janicki (2004)
Compilation of NWT top data from hydrocarbon exploration wells	Janicki (2005)
Compilation of 595 samples collected for a Mississippi Valley-type deposit study in southern NWT and northern Alberta	Hannigan (2005a)
Compilation of 822 Pb-Zn occurrences in southern NWT and northern Alberta	Hannigan (2005b)
Mississippi Valley-type deposit potential of the southern NWT and northern Alberta	GSC Bulletin 591; P.K. Hannigan ed. (2006b)

Important data gaps include the lack of detailed surficial mapping in the eastern half of the study area (NTS areas 85 C and 85 E), the lack of radiometric and national geochemical reconnaissance data and a low level of mineral exploration data.

REGIONAL GEOLOGY

Overview

The study area is located in the Interior Platform geological province that is composed of sedimentary cover rocks that overlie Precambrian basement and are capped by Quaternary units and by recent sediments and organic deposits. Cover rocks of the Western Canada Sedimentary Basin (WCSB) form a wedge that increases in thickness towards the southwest. In the southwestern portion of the study area, cover rocks reach a thickness of about 1650 m.

The WCSB contains two major sedimentary successions; an older succession of Proterozoic to mid-Jurassic marine sediments deposited on a passive continental margin and a younger succession of Late Jurassic to Tertiary rocks derived from the erosion of the evolving Cordilleran Orogen to the west. The zero edge of basin where Precambrian rocks are exposed at surface lies about 250 km east of the study area.

Basement rocks

Interpretation of basement domains beneath the WCSB have been made from aeromagnetic, gravity and seismic data supplemented by geochronological and isotopic information obtained from wells that penetrate the Phanerozoic cover (e.g. Hoffman, 1988; Ross et al., 1989; Villeneuve et al., 1993; Burwash et al., 1994; Ross, 2002; Pană, 2003; and Aspler et al., 2003). An understanding of basement domains has also been increased by data collected as part of the Lithoprobe study.

Regional basement domains are shown on Figure 3 and include Archean cratons (Slave and Rae Provinces), Proterozoic accreted terranes (Hottah, Buffalo Head and Chinchaga) and magmatic arcs (Taltson, Great Bear, and Ksituan). As interpretations are largely based on indirect geophysical evidence, several tectonic scenarios have been advanced to explain the evolution of Proterozoic crust along the western margin of Laurentia. The following discussion provides a general overview.

The Buffalo Head domain is an area of Paleoproterozoic crust (2.34 to 1.99 Ga; Villeneuve et al., 1993) that underlies north-central Alberta. Isotopic studies suggest this domain may have developed on pre-existing Archean crust. About 2.0 Ga, the Slave Craton and the amalgamated Buffalo Head-Chinchaga domains drifted towards the northeast and collided with the western side of the Rae Province. Subduction along a suture zone resulted in the development of magmatic arcs (e.g. Taltson Magmatic Zone). Indentation of the Rae Province by the Slave craton resulted in the formation of the Great Slave Lake shear zone (GSLsz; Hoffman, 1987) that underwent about 700 km of dextral strike-slip motion between 1.98 and 1.92 Ga (Hanmer et al., 1992). A younger phase of brittle movement (1.86-1.74 Ga) resulted in up to 125 km of dextral offset on the sub-parallel McDonald fault system (Hanmer et al., 1992).

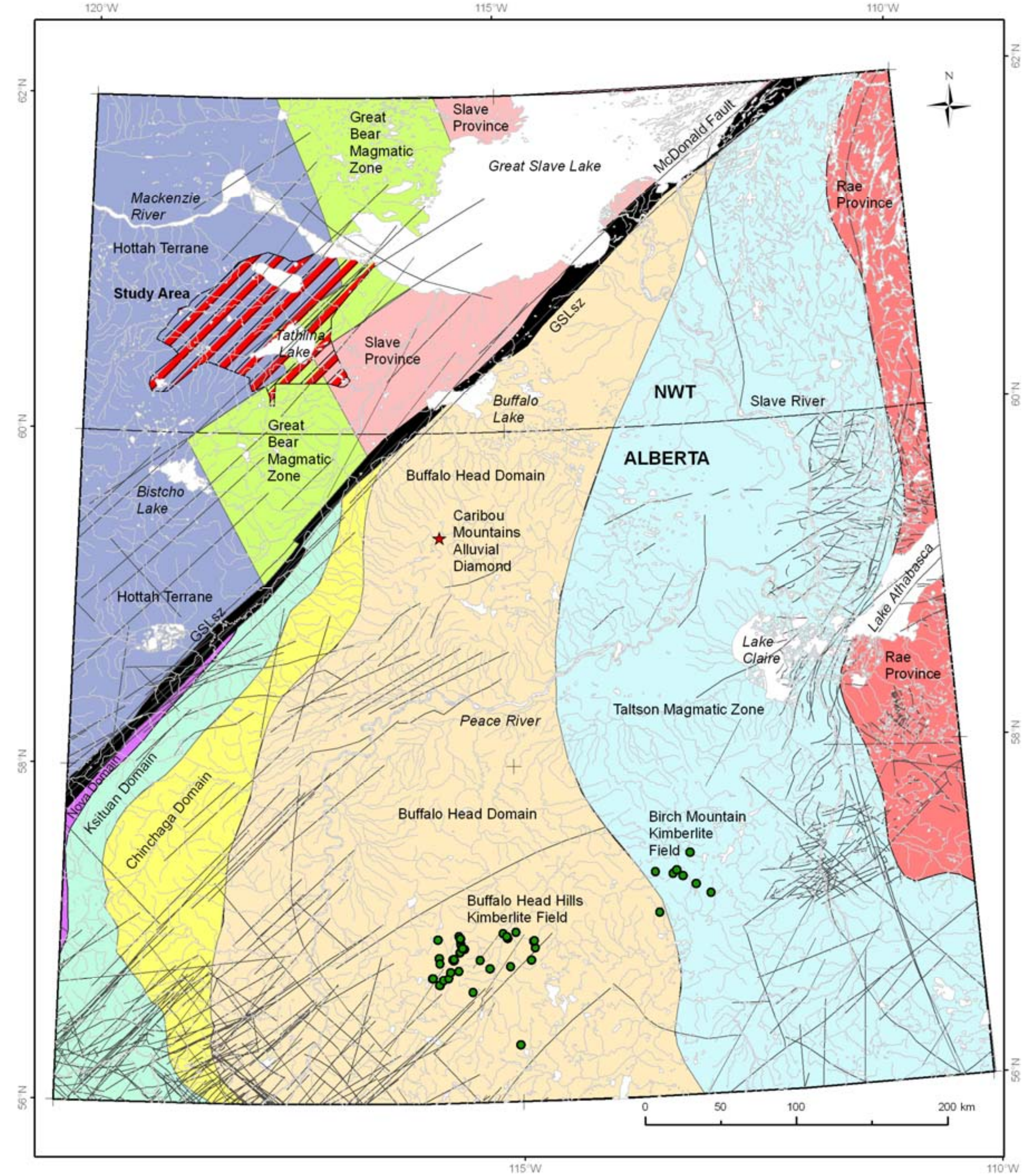

Figure 3. *Interpreted basement domains and structural lineaments from Pană and Waters (2003). Alberta diamondiferous kimberlite locations and alluvial diamond occurrences from Eccles (2007).*

At the onset of the collision between the eastern Slave and Rae provinces, the western edge of the Slave craton was a passive margin that accumulated sedimentary rocks. Between 1.9 and 1.88 Ga, the Hottah terrane, a 2.1 to 1.9 Ga volcanic arc, accreted on the western side of the Slave Province (Cook and Erdmer, 2005). This collision resulted in eastward directed subduction of oceanic lithosphere that produced a continental magmatic arc (Great Bear magmatic zone, 1.88 to 1.84 Ga; Gandhi et al., 2001.). The Great Bear magmatic zone terminates to the south against the GSLsz.

Following accretion and arc magmatism, the region underwent a period of crustal extension. Extension initiated in the late Paleoproterozoic led to the development of a long-lived sedimentary basin (Fort Simpson basin) that continued to accumulate sediments until ca. 0.8 Ga (Cook and Erdmer, 2005). Thick accumulations of Proterozoic sedimentary rocks are found beneath the Great Bear Plain to the north, but are absent beneath the study area. Rifting associated with the initial development of the Cordilleran miogeocline affected the area between 0.75 and 0.55 Ga.

Cover Rocks – Western Canada Sedimentary Basin

Within the study area, pre-Devonian uplift and erosion removed Lower Paleozoic strata that are preserved in the subsurface in areas far to the west near the Cordilleran Orogen. Warping of the pre-Devonian surface created a series of gentle arches and basins in the Precambrian basement. The Tathlina Arch (Figure 4) was a northwest-trending basement high that persisted until the Late Devonian and affected sedimentation within the study area (Meijer Drees, 1993). In the Great Slave Plain, earliest preserved Phanerozoic rocks are of Early Devonian age and were deposited in a restricted basin on the margins of the Tathlina Arch. Basal clastic units (La Loche) are overlain by interbedded shale, evaporites and minor carbonate of the Mirage Point and Lower Chinchaga formations (Table 3).

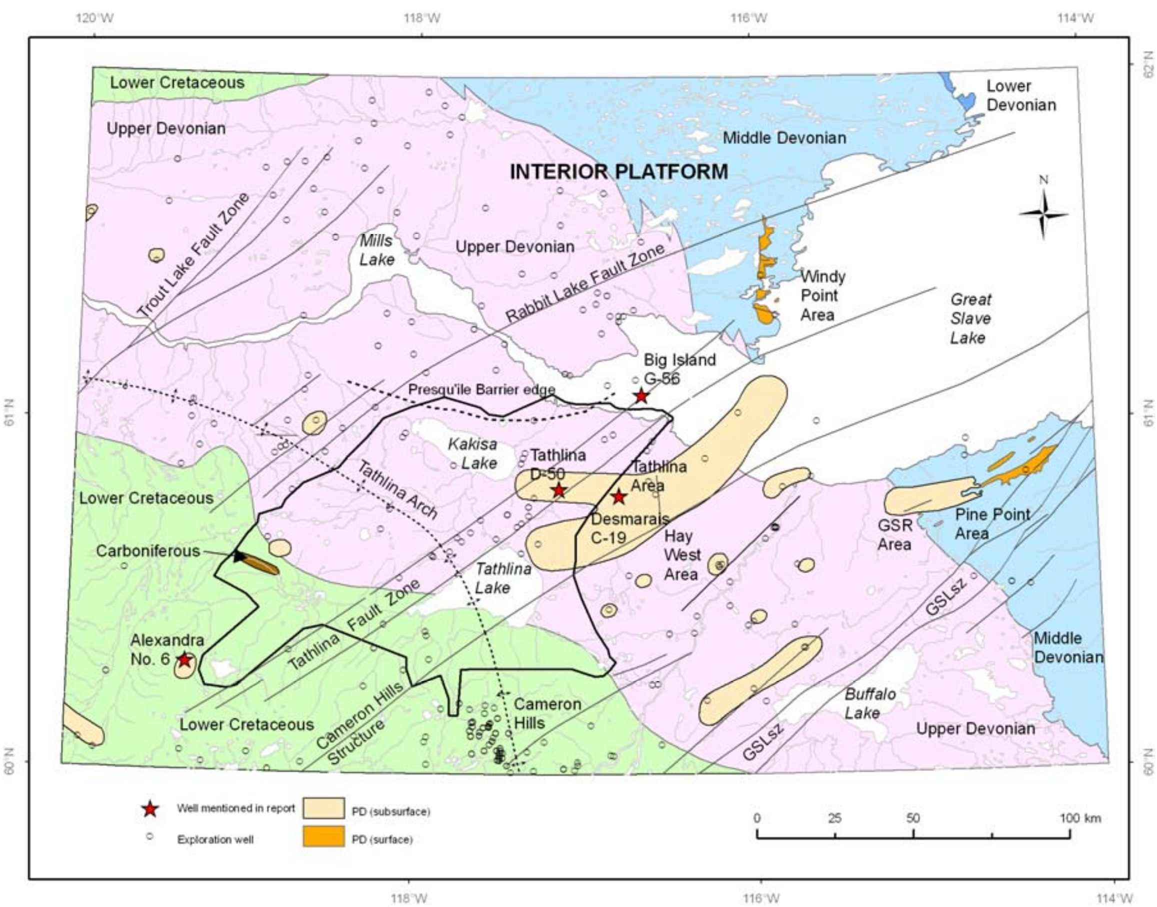

Figure 4. *Phanerozoic geology showing the surface and subsurface location of Presqu'ile dolomite (PD) adapted from Okulitch and Fallas (2007). Location of hydrocarbon exploration wells from National Energy Board (2007).*

The Middle Devonian succession unconformably overlies the Lower Devonian rocks and sedimentation began with the deposition of platformal carbonates during a marine transgression. During upper Middle Devonian time (Givetian), the Presqu'ile barrier reef complex developed over the Tathlina Arch (Meijer Drees, 1993). This barrier separates the open marine Mackenzie sub-basin to the north from the restricted Elk Point basin to the south. The barrier complex consists of shallow water carbonates and separates evaporites and lesser carbonates deposited in the restricted basin from deeper water marine deposition to the north.

Table 3. Table of formations

Period (Epoch, stage)		**Formation / Group**	**Lithology**
Holocene		Unnamed	Organic deposits
Quaternary		Unnamed	Glacial and glaciolacustrine sediments
Unconformity			
Tertiary	Eocene to Paleocene	Buffalo Head domain kimberlite and kimberlites from Slave Craton[1]	Ca. 64 to 60 Ma kimberlites in the Buffalo Head domain (Alberta Geological Survey, 2007). Diamondiferous Slave kimberlites from Lac des Gras field commonly 56 to 51 Ma (Creaser et al., 2004).
Cretaceous	Upper	Buffalo Head domain kimberlite and kimberlites from Slave Craton[1]	Ca. 88 to 81 Ma kimberlites in Buffalo Head domain (Alberta Geological Survey, 2007). Upper Cretaceous Slave kimberlites commonly have lower diamond potential (Creaser et al., 2004).
	Upper / Lower	Fort Saint John Group and equivalents	Shale, with minor siltstone and sandstones
Unconformity			
Carboniferous	Lower	Banff	Shale, sandstone and limestone
Devonian	Upper	Kotcho	Shale, limestone and sandstone
		Tetcho	Limestone
		Trout River	Limestone, siltstone and minor sandstone
		Kakisa	Limestone
		Redknife	Shale and limestone
		Fort Simpson	Shale
		Tathlina	Siltstone, shale and limestone
		Twin Falls	Limestone
		Hay River	Shale and limestone
	Middle to Upper	Muskwa	Shale
	Middle	Slave Point	Limestone and dolostone
		Watt Mountain	Shale and limestone
		Unconformity	
		Sulphur Point[2]	Limestone and dolostone
		Muskeg	Anhydrite and dolostone
		Keg River and Lonely Bay	Dolostone and limestone
		Upper Chinchaga	Anhydrite, minor limestone and dolostone
		Ebbutt Member	Shale, sandstone and siltstone
	Unconformity		
	Lower	Lower Chinchaga	Anhydrite
		Mirage Point	Anhydrite, dolostone and evaporites
		Basal Clastics (La Loche)	Sandstone
Unconformity			
Precambrian		Slave craton, GSLsz and Buffalo Head domain	Metamorphosed supracrustal and intrusive rocks; mylonites

Adapted from Lemieux (2007) and from Okulitch and Fallas (2007)
[1]*kimberlites are not known to occur in the study area*
[2]*hydrothermal Presqu'ile dolomite most commonly developed in the Sulphur Point Formation*

A regression in mid-Givetian time intermittently exposed the barrier reef. The Watt Mountain Formation was deposited above the unconformity. At this time, carbonate rocks of the barrier may have undergone initial karstification. A subsequent transgression deposited the Slave Point Formation across the region. Upper Devonian sedimentation was marked by fluctuating base levels that deposited intermixed carbonate platform and clastic wedges. Suspected units of Carboniferous strata are locally present at surface near Tathlina Lake (Okulitch and Fallas, 2007).

Lower Cretaceous units (Fort Saint John Group) unconformably overlie the Devonian and Carboniferous strata (Dixon, 1999). These rocks consist of cyclical units of sandstone and shale deposited in a foreland basin from the uplifted and actively eroding Cordilleran Orogen to the west. Cretaceous units form upland areas and underlie the Cameron Hills along the southern margin of the study area.

The Presqu'ile dolomite is a coarse crystalline dolostone that locally overprints Middle Devonian rocks of the Presqu'ile barrier complex. This unit was initially interpreted as the dolomitized core of the barrier reef before it was recognized as a secondary diagenetic facies. Presqu'ile dolomite is concentrated in the Sulphur Point Formation but is also developed in the upper Keg River and lower Slave Point formations (Janicki, 2006). Janicki (2006) also notes that possible Presqu'ile dolomite was also identified in rocks as old as the upper Chinchaga Formation. Further to the west in the Liard Plain, the compositionally similar Manetoe dolomite overprints Early and Middle Devonian strata.

Regional Structures

Regional structures have been previously interpreted from offsets or truncations in stratigraphy, from an analysis of sub-surface contour maps and from the interpretation of geophysical data (e.g. Pană et al., 2001; Pană, 2003 and 2006, Pană and Waters, 2003; MacLean, 2006; and Morrow et al., 2006). The study area is characterized by an orthogonal pattern of lineaments with a prominent northeast-trending set and a weaker northwest orientation (MacLean, 2006). Many lineaments are suspected to correspond to faults that may play an important role in controlling sedimentary depositional patterns, the migration and trapping of hydrocarbons and the focusing of fluids to create base metal deposits. The empirical association between lineaments and base metal mineralization in the Pine Point area dates back to the 1930s (Kidd, 1936) and the regional relationship between lineaments and facies patterns in Devonian carbonate units was noted by Belyea (1971). Some regional structures are suspected to have originated during the Proterozoic with subsequent episodes of reactivation during Paleozoic and Mesozoic time.

Important northeast-trending structures are outlined on Figures 4 and 5 and include:

- Great Slave Lake shear zone (GSLsz)
- McDonald fault
- Cameron Hills structure (previously called the Hay River fault zone)
- Tathlina fault zone
- Rabbit Lake fault zone

As the term Hay River fault zone has been applied to several different structures in northern Alberta and the southern NWT, Morrow et al. (2006) proposed the name Cameron Hills structure to refer to a northeast-trending lineament at the south side of Tathlina Lake. This nomenclature is used in this report. In addition to major structures, the region is also cut by smaller sub-parallel northeast-trending structures that have not been named.

Quaternary and Recent sediments

Most of the study area consists of a very gently sloping moraine plain that is overlain by organic deposits in the Great Slave Lake Lowlands and on the Tathlina Plains. Organic deposits are less common on the Cameron Slopes and glaciofluvial deposits are locally found in small meltwater channels. Areas underlain by glaciolacustrine sediments and recent alluvial deposits are found near Great Slave Lake and the Mackenzie River. Alluvial deposits are also found along the Kakisa River.

REGIONAL EXPLORATION

Base Metals

Initial discovery of lead-zinc mineralization was made in the Pine Point area where the Presqu'ile dolomite and associated mineralization is exposed at surface. Early exploration was also undertaken on the northwest side of Great Slave Lake where the hydrothermal dolomite is exposed. Subsequent exploration for blind deposits has been undertaken towards the west where the favourable units for replacement by hydrothermal dolomite are progressively covered by overlying formations. Exploration areas described in the next section are shown on Figure 5.

Pine Point area

The presence of sulphide mineralization in the Pine Point area was known to aboriginal peoples and was reported to prospectors en-route to the Klondike gold fields. Claims were staked to cover surface exposures of lead-zinc in 1897 but interest waned after testing revealed the mineralization did not have associated silver (McGlynn, 1971). The area was visited by R. Bell of the Geological Survey of Canada in 1899 who reported on the mineralization (Bell, 1902). Limited exploration was undertaken in 1908 and 1914 with a more extensive program initiated in 1920. In 1929, Consolidated Mining and Smelting Company (Cominco Ltd.) became involved in exploration and by 1930, drilling and shaft sinking had outlined about 500,000 tons of lead-zinc ore (McGlynn, 1971). At this time, J.M. Bell reported the similarities of the Pine Point mineralization to that of the Tri-State area in Missouri (Bell, 1929).

Further exploration interest was stimulated after Kidd (1936) reported the spatial association of lead-zinc mineralization with the surface trace of basement faults. The property and exploration data were re-examined by Cominco in 1940 and the potential for additional mineralization along strike from the discovery area was recognized (McGlynn, 1971). In 1948, Cominco acquired a large prospecting concession and began a regional exploration program. Pine Point Mines Ltd, a new company controlled by Cominco, was formed in 1951 and staked mineral claims within the concession. Between 1948 and 1954, exploration consisted of geophysical surveys, shaft sinking and a large regional grid drilling program. A baseline was established along the inferred trend of basement faults and series of diamond drill holes were completed at one mile intervals. Sections at right angles to the baseline were drilled off on 1000 foot centres. Tighter drill spacing was used to evaluate areas with favourable mineralization. After 1963, exploration drilling was also guided by geophysics.

Initial reserves were estimated at 8.8 million tons of ore averaging 2.6% Pb and 5.9% Zn. A decision to put the mine in production was made in 1960 with production starting in 1964. Production continued between 1964 and 1988 at which time 64.3 Mt at about 3% Pb and 7% Zn were mined from 50 ore bodies (Hannigan, 2006a). An additional 50 orebodies identified by diamond drilling were not placed into production. Exploration data compiled by Hannigan (2006b; Table 1) suggests the camp may contain up to 34.8 Mt of reserves (Table 4).

Table 4. Reserves and resources of the Pine Point camp

Category	Source	Estimate
Reserves[1]	Hannigan (2006b)	34.8 Mt
Probable reserves	Tamerlane Ventures Inc. (2007)	1 Mt @ 5.49% Pb and 11.16% Zn
Indicated resources	Tamerlane Ventures Inc. (2007)	10.9 Mt @ 2.43% Pb and 4.69% Zn
Historic resources[2]	Tamerlane Ventures Inc. (2007)	50.9 Mt @ 1.24% Pb and 3.84% Zn

[1]Estimate obtained by summing Reserve Tonnes column in Table 1, Pine Point district orebodies (Hannigan, 2006b).
[2] Historic resources were tabulated from exploration data taken from Westmin and Cominco. As a qualified report on historic resources has not been undertaken, they are not included in the current resource estimate of the property, although they provide an indication of possible remaining mineral potential.

The remaining potential of the camp has also been evaluated by Tamerlane Ventures Inc. who has outlined 1 Mt of probable reserves at 5.49% Pb and 11.16% Zn and 10.9 Mt of indicated resources at 2.43% Pb and 4.69% Zn from a total historical resource base of 50.9 Mt (Tamerlane Ventures Inc., 2007).

Great Slave Reef (GSR) area

The GSR area lies to the west of the Pine Point mine property and forms the western extension of the Pine Point camp. Unlike the Pine Point mine property where the Presqu'ile barrier and associated mineralization is locally exposed at surface, the favourable unit in the GSR area is progressively buried towards the west. Showing data compiled by Hannigan (2005b) indicates the top of the mineralization varies from about 45 m depth in the east to about 150 m in the west This hindered initial exploration, as conventional induced polarization geophysics could not be used to guide exploration.

The GSR property was acquired by Western Mines in 1975 and drilling was undertaken up to 1985 outlining seven ore bodies. A summary of exploration data from more than 900 diamond drill holes on the GSR property was compiled by Turner et al. (2002). The GSR property was subsequently acquired by Tamerlane who undertook additional drilling on historical deposits and completed a feasibility study on the R190 deposit. In August of 2007, Tamerlane announced their intention to begin underground mining the R190 deposit using a perimeter freeze technique to control ground water (Tamerlane Ventures Inc., 2007).

Hay West area

The Hay West area lies to the west of the GSR area and covers the westward extension of the Presqu'ile barrier. Claims were staked in 1978 by joint venture partners lead by Cominco. Between 1978 and 1981 work included seismic and gravity surveys and 19,422 m of diamond drilling in 42 drill holes (Klein, 1982). This work outlined the Presqu'ile dolomite in the subsurface and demonstrated that collapse structures in the barrier could be identified by seismic surveys. Three diamond drill holes found a thick breccia sequence but only minor quantities of lead-zinc mineralization.

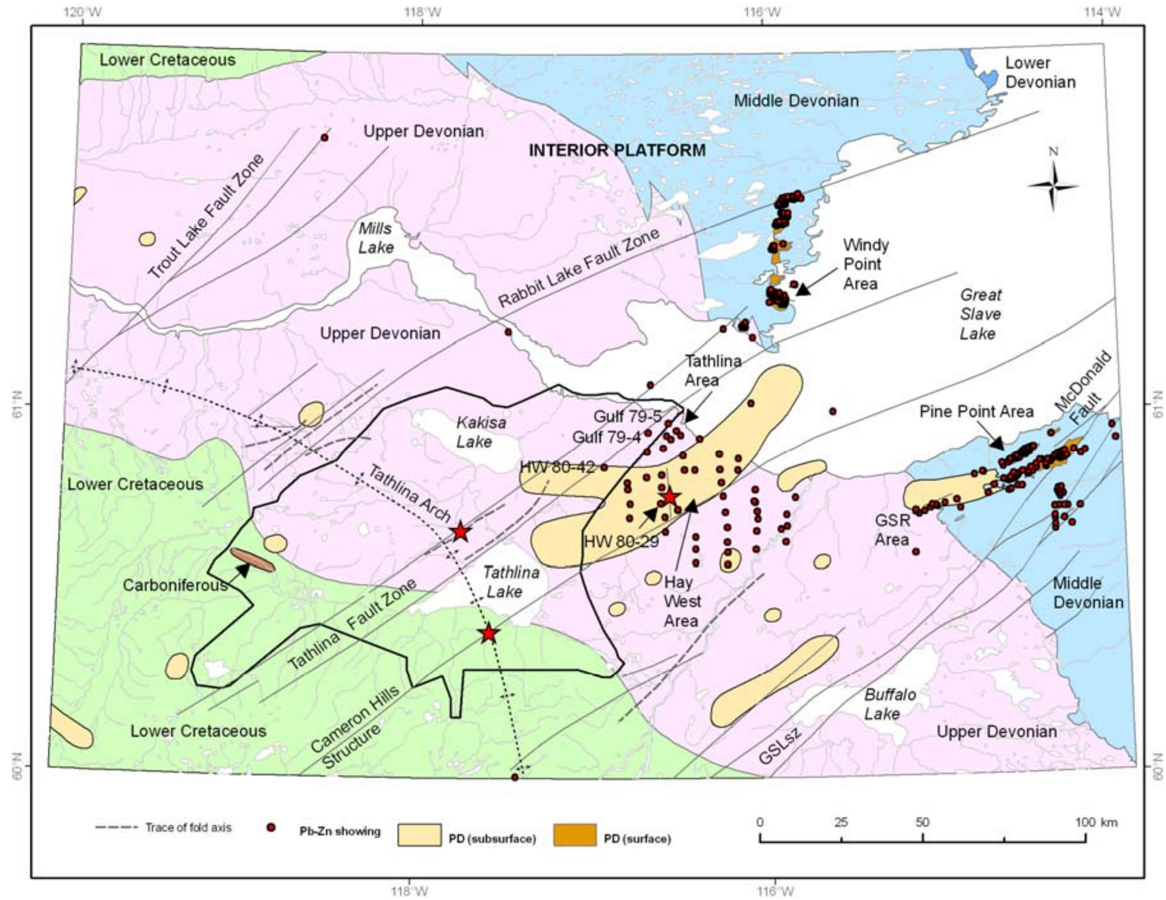

Figure 5. *Phanerozoic geology adapted from Okulitch and Fallas (2007) showing the surface and subsurface location of Presqu'ile dolomite (PD). Locations of Pb-Zn showings from Hannigan (2005b). Red stars mark areas of higher base metal potential identified by Hannigan (2006b).*

Tathlina Lake area

In the 1970s, Gulf Canada Minerals Ltd. began a program looking for buried lead-zinc deposits northeast of Tathlina Lake. This effort was driven by the subsurface presence of the Presqu'ile barrier and associated Presqu'ile dolomite facies, proximity to known basement structures (Tathlina fault) and by the recognition of galena and sphalerite in chip samples obtained from wells undertaken for hydrocarbon exploration (Germundson, 1980). The program started with the completion of a diamond drill hole adjacent to hydrocarbon exploration well (Desmarais C-19) to confirm the presence of lead-zinc mineralization. Other work included ground electromagnetic surveys, six diamond drill holes and downhole geophysical logging (Germundson, 1980). This work confirmed the subsurface presence of the Presqu'ile dolomite, but failed to encounter significant mineralization. Exploration data was used to conclude that the thickest development of Presqu'ile-type dolomitization was associated with the hinge lines of regional structures. Unpublished exploration data from this program was donated to the NWT Geology Archives and is on file at the NWT Geoscience Office in Yellowknife.

Windy Point area

In 1955, the Windy Point Mining Company staked claims on the northwest side of Great Slave Lake to cover units of Presqu'ile-like dolostone. Mapping, prospecting and about 20,000 feet of diamond drilling (120 holes) were completed. Sporadic lead-zinc mineralization was detected although economically significant concentrations were not found (McGlynn, 1971).

Diamond Exploration

Early indicators of the diamond potential of the north include the discovery of kimberlites on Somerset Island in 1970 and by the recognition of kimberlites in the Mackenzie Mountains in 1977 (GNWT, 2005). Between 1979 and 1982 Diapros Canada Ltd, a subsidiary company of DeBeers, undertook diamond exploration in the Blackwater Lake area and in the mid-1980s BP Resources conducted regional diamond exploration over a large portion of the northern Interior Platform. Diamond exploration in the Interior Platform has identified numerous kimberlite indicator minerals (described in Gal and Lariviere, 2004). After the discovery of diamond deposits in the Slave craton in the early 1990s, it was commonly assumed that kimberlite indicator minerals of the Interior Platform were glacially transported into the area from sources to the east. On-going diamond exploration (e.g. Diamondex Lena West project; Figure 1) continues to evaluate the potential for kimberlite sources within the Interior Platform. In 2007, Sanatana Diamonds announced the discovery of a diamondiferous kimberlite in the Greenhorn area near the eastern margin of the Interior Platform northeast of Great Bear Lake (Sanatana Diamonds Inc., 2007). This area is interpreted to be underlain by basement rocks of the Hottah terrane. In 2008, Olivut Resources Ltd. announced the discovery of seven kimberlites in rocks of the Interior Platform south of Great Bear Lake (Olivut Resources, 2008).

Farther south in Alberta, diamondiferous kimberlites have been identified in the Buffalo Head domain. Exploration in northern Alberta has also identified an alluvial diamond from the Caribou Mountains (Eccles, 2007) and an alluvial diamond has been found in the Edehzhie area (Horn Plateau) to the northwest of the study area (Day et al., 2007).

REGIONAL METALLOGENIC STUDIES

In addition to knowledge provided by company exploration efforts, the potential of the study area to contain lead-zinc mineralization has also been the focus of a collaborative study between the Geological Survey of Canada, provincial and territorial surveys and university researchers. Some of the results of this study are contained in Geological Survey of Canada Bulletin 591 (Potential for Carbonate-Hosted Lead-Zinc Mississippi Valley-type Mineralization in Northern Alberta and Southern Northwest Territories; P.K. Hannigan ed., 2006b). This study focused on determining the source, movement and trapping of mineralizing fluids and undertook a metallogenic synthesis by placing MVT deposits within the regional structural and stratigraphic framework. Important highlights relevant to the assessment of mineral resources in the study area include:

- Further confirmation of the importance of structural control on lead-zinc mineralization
- Subsurface mapping of the distribution of Presqu'ile dolomite
- Metallogenic model of the formation of MVT deposits
- Mineral prospectivity mapping and ranking of mineral potential

LOCAL GEOLOGY

The study area is underlain by the Archean Slave Province, the Great Bear magmatic zone and by the Hottah terrane (Figure 3). Depth to basement ranges from about 530 m in the north (Big Island G-56 well) to about 1650 m in the south (Alexandra No. 6 well). Well locations are indicated on Figure 4 and depth to basement is taken from Janicki (2005).

Phanerozoic cover rocks dip gently towards the southwest and successively older formations are exposed at surface towards the northeast. Over most of the study area, units exposed at surface consist of Upper Devonian limestone and shale (Hay River to Kotcho formations). Cretaceous shale with minor siltstone and sandstone (Fort Saint John Group) unconformably overlie Devonian rocks in the southern portion of the study area in the Cameron Hills.

Within the study area, Middle to Lower Devonian rocks are found in the subsurface and are known from about 38 hydrocarbon exploration wells (Figure 4). The carbonate-dominated Middle Devonian sequence is particularly important to the mineral assessment of the study area as these rocks are locally overprinted by hydrothermal dolomite and host the world class Pine Point lead-zinc deposits in areas to the east. Most of the study area is underlain by carbonate units deposited on the Presqu'ile barrier complex. The edge of the Presqui'ile barrier complex (Meijer Drees, 1993) is located northeast of Kakisa Lake and lies along the northeastern margin of the study area (Figure 5).

The Slave Point Formation, the uppermost Middle Devonian unit, is found at a depth between about 200 m in the northeast (Big Island G-56 well) to about 1400 m in the southwest (Alexandra No. 6 well). In the Tathlina D-50 well (Figure 4) the top of the Middle Devonian sequence is found at a depth of about 560 m. In areas further to the southwest, the Middle Devonian sequence is progressively buried and increasingly less accessible for base metal exploration and development.

Previous mineral exploration for base metal mineralization was undertaken near the northeast margin of the study area where Middle Devonian units are found in the shallow subsurface. A compilation by Hannigan (2005b) recognized three occurrences in the study area near the Tathlina fault zone (Figure 5). Drill hole HW 80-42 contained up to 203 ppm Pb between a depth of 243 and 249 m. Gulf drill hole 79-4 returned 470 ppm Pb between 490.7 and 534.3 m and drill hole 79-5 returned 132 ppm Pb and 1750 ppm Zn between 426.8 and 429.8 m (Hannigan, 2005b). Several showings were also identified to the east of the study area in the Hay West exploration area. Drill hole HW 80-29 is located about 15 km east of the study area and returned 0.27% Pb and 1.6% Zn between 547 and 550 m (Hannigan, 20005b). This area was identified as zone of high to moderate mineral potential by Hannigan (2006b).

The subsurface extent of hydrothermal Presqu'ile dolomite has been mapped from information provided by hydrocarbon exploration wells and base metal exploration drill holes (e.g. Janicki, 2006; Okulitch and Fallas, 2007). Presqu'ile dolomite is developed between the Tathlina fault zone and the Cameron Hills structure (Figure 5). At this location, the thickness of Presqu'ile dolomite locally exceeds 100 m and Janicki (2006) notes that the greater thickness appears to be coincident with a basement graben structure between the two fault zones. Janicki (2006) also observes that Presqu'ile dolomite thins towards the southwest and is not present below a depth of about 850 m where Devonian strata are covered by Cretaceous rocks. A similar distribution of Presqu'ile dolomite was presented by Okulitch and Fallas (2007), although these authors have mapped small units of hydrothermal dolomite in the deep subsurface (Figure 5). MacLean (2006) noted that hydrothermal thermal dolomitization appears to be indirectly enhanced by adjustments on some basement features (e.g. Tathlina fault zone) but not on others (e.g. Rabbit Lake fault zone).

In summary, the subsurface geology of Middle Devonian carbonate-dominated strata is known from widely-spaced drill holes. This information suggests hydrothermal dolomite is most common in the eastern portion of the study area where it appears to be associated with major northeast-trending structures (Tathlina fault zone and the Cameron Hills structure). In the northeastern portion of the study area, favourable Middle Devonian carbonate rocks are found at depths less than about 500 m. This area has been explored for base metals by widely-spaced drill holes that have found thick zones of hydrothermal dolomite that locally contain low concentrations of lead and zinc.

MINERAL ASSESSMENT

Mississippi Valley-Type Deposits (MVT)

MVT deposits are stratabound accumulations of lead and zinc that are commonly linked to the large-scale migration of fluids in sedimentary basins. Lead and zinc sulphide minerals are locally concentrated in platform carbonate sequences that are connected to larger basins that were affected by orogenic events. MVT deposits show a temporal association with large-scale compressional events. The most prospective time period (Devonian to Permian) is thought to coincide with the assembly of the supercontinent Pangaea (Paradis et al., 2007). Deposits are characterized by open-space fillings within dolomitized, karsted, and brecciated carbonate units.

MVT deposits are part of a spectrum of sediment-hosted base metal deposits which include SEDEX, sandstone-hosted lead deposits, Irish-type Zn-Pb deposits, carbonate-hosted Cu-Pb-Zn deposits (Kipushi type), and Broken Hill-type Pb-Zn deposits. SEDEX deposits are commonly found in the deeper water portion of the adjacent basin to the MVT host (Paradis et al., 2007).

Although MVT deposits are thought to form by the migration of warm, saline hydrothermal fluids in sedimentary basins, several different mechanisms have been proposed to drive circulation including:

- Topographic or gravity driven models (e.g. Garven, 1985)
- Sedimentary compaction models (e.g. Jackson and Beales, 1967)
- Hydrothermal convection models (Morrow, 1998)

The recently completed study of the MVT potential of the southern NWT favoured the hydrothermal convection model of the genesis of the MVT deposits in the Pine Point camp (Hannigan, 2006b). In this model, metals were derived from upwelling hydrothermal fluids from basement faults and deposited in structural sites at higher stratigraphic levels. Basement structures are also thought to influence the location and development of carbonate barrier reefs and their subsequent karstification and dolomitization.

Hannigan (2006b) outlined a number of criteria for determining MVT potential in the Pine Point Camp (Table 5) and developed a mineral prospectivity map. This mapping exercise predicted a moderate MVT potential for areas adjacent to major northeast-trending structures and a high to moderate potential for areas where northeast-trending structures are crossed by folds or intersecting lineaments. Several areas of higher mineral potential identified by Hannigan (2006b) are shown on Figure 5.

Table 5. Hannigan's (2006b) criteria for MVT prospectivity mapping near Pine Point

Class	Criteria
Diagnostic	MVT mineralization or occurrences
	Pb-Zn anomalies in bedrock or surficial materials
	Presqu'ile dolomite
	Proximity to faults or fractures
	proximity to basement lineaments
	proximity to basement highs
	proximity to carbonate barrier complex
	proximity to paleokarst network
Permissive	relation to carbonate aquifers
	proximity to evaporites
	relation to aquiclude cap-rocks
	association with hydrocarbons
	marcasite or pyrite haloes
	proximity to surface (outcrop or subcrop)

The study area contains many of the criteria outlined in Table 5, including proximity to faults, the development of Presqu'ile dolomite, and the development of weak lead-zinc mineralization. The area also exhibits an association with hydrocarbons in the Presqu'ile barrier (Morrow, 2007). The only criteria not met for the study area is a proximity to surface.

The setting of the study area near the Tathlina fault zone and Cameron Hills structure is similar to the Pine Point area, where secondary structures adjacent to large northeast-trending basement faults are replaced by hydrothermal dolomite and Pb-Zn mineralization. The thickness of hydrothermal dolomite is also similar to that developed in the Pine Point camp. It is also important to note that the study area has only been investigated by widely-spaced drill holes and that exploration was guided by geophysical techniques and processing methods that were available in the late 1970s and early 1980s. In Pine Point camp, individual ore-bodies commonly form small targets (i.e. vertical, rod-like accumulations) that are difficult to find with widely-spaced drill holes. As the geological environment is favourable but significant deposits have not been identified, the northeast portion of the study area is considered to have a moderate to high mineral potential for MVT deposits.

In addition to MVT deposits, the study area could also contain other varieties of sediment-hosted deposits. Hannigan (2005b) identified 822 lead-zinc occurrences in the regional area, the majority of which were classified as MVT. About 5% of the occurrences did not fit the profile of MVT deposits and were considered to be other types of stratiform sediment-hosted deposits (Hannigan, 2006a). As most of the study area is underlain by the Presqu'ile barrier complex, other sediment-hosted deposit types appear to be of lesser importance and were not specifically assessed in this study.

An assessment of MVT potential also needs to consider economic factors which can change over time. In this case, it is instructive to review mine development in the regional area. The Pine Point deposits were long known to aboriginal inhabitants and about 60 years elapsed between the staking of the first mineral claims and production of lead-zinc concentrate. Initial mining efforts focused on near-surface deposits that could be exploited by open pit mining. The subsurface extension of Pine Point main trend into the GSR area has been known since the mid-1960s and only recently have proposals been put forward to mine shallow deposits in this area by underground methods. Similarly, the potential for subsurface mineralization within dolomitized rocks of the Presqu'ile barrier complex farther to the west has been recognized since the mid-1970s. Currently, the challenges associated with locating mineralization within the deep subsurface appear daunting, although it is hard to predict what future advances in technology could bring. An important finding of pioneering exploration efforts in the late 1970s was the recognition that structures associated with mineralization could be detected by seismic methods. Future improvements in imaging technology could make direct detection of buried deposits possible. It is also important to consider the historical relationship between hydrocarbon exploration and the search for lead-zinc deposits. The general trend has been the recognition of base metals from wells initially targeting hydrocarbon resources. Increased exploration for hydrocarbons could also provide data to assist lead and zinc exploration. In any event, advances in imaging technology will likely be driven by hydrocarbon exploration with base metal exploration benefiting from refinements in the technology.

In summary, the study area has moderate to high potential to contain MVT deposits adjacent to fault zones. From an economic standpoint, mineral potential decreases towards the southwest as favourable horizons are progressively found at greater depths. Currently, the discovery of lead-zinc resources in the subsurface appears unlikely, although this situation could change with future technological developments.

Primary Diamond Deposits

Primary diamonds can be found in kimberlite and lamproite intrusions, which act as transport mechanisms to move diamonds to higher crustal levels. Kimberlite magmas can move diamonds from thick, old, cold lithosphere mantle roots at depths greater than ~150 km to the Earth's surface (Kjarsgaard, 1995a). Areas underlain by thick, stable crust (cratons) are commonly considered to be more prospective for diamondiferous kimberlites.

Kimberlites can also be found outside of cratonic areas, although this setting is conventionally considered to be less prospective. It is important to note that diamond exploration is taking place in off-craton areas such as Proterozoic accreted terranes (e.g. Diamondex Lena West project and Sanatana Diamonds Greenhorn project; Figure 1), and that the mineral potential of these areas is known with less certainty. Areas not underlain by thick, stable crust, such as mobile belts adjacent to cratons, may also be prospective for diamonds carried in lamproites (Kjarsgaard, 1995b), although fewer of these occurrences have been found.

The eastern portion of the study area is underlain by Archean rocks of the Slave Province which is a favourable geological environment for diamondiferous kimberlites (Table 6). The Hottah and Great Bear magmatic zones are interpreted to underlie the remainder of the study area. Diamondiferous kimberlites have been reported from the Greenhorn project area (Sanatana Diamonds Inc., 2007) an area underlain by the Hottah terrane. No exploration data to assess the potential of kimberlites is available for the study area. The region is considered to have low to moderate potential for diamonds with a low level of certainty.

Table 6. Assessment criteria for primary diamond deposits

Criteria	Study area
Presence of thick continental crust, such as found below stable Archean cratons, is most prospective for diamonds in kimberlite	The eastern portion of the study area is underlain by the Archean Slave craton.
Margins of cratons, including accreted mobile belts may be prospective for diamonds in lamproites	Study area lies along the margin of the Archean Slave craton and is potentially prospective for diamonds in lamproites.
Deposits known in study area or region	No diamond deposits are known in study area. The Archean Slave craton hosts diamondiferous kimberlites in areas outside of the study area. The northern interior platform contains kimberlite indicator minerals and continues to undergo diamond exploration. Diamondiferous kimberlites have been reported from the Greenhorn area underlain by the Hottah terrane. Alluvial diamonds have been reported northwest and south of the study area.

Summary of Mineral Potential

A summary of mineral potential for the Ka´a´gee Tu study area is present in Table 7.

Table 7. Summary of mineral potential

POTENTIAL RANKING	CONFIDENCE RANKING			
	Rank 1: Abundant reliable information	**Rank 2:** Moderate amount of information	**Rank 3:** Some information	**Rank 4:** Very little or unreliable information
Rank A – Very High: Geologic environment is favourable. Significant deposits are known. Presence of undiscovered deposits is very likely.				
Rank B – High: Geologic environment is favourable. Occurrences are present but significant deposits are not known. Presence of undiscovered deposits is likely.				
Rank C – Moderate to High: Intermediate between moderate and high potential.			MVT deposits	
Rank D – Moderate: Geological environment is favourable. Occurrences may or may not be known. Presence of undiscovered deposits is possible.				
Rank E – Low to Moderate: Intermediate between low and moderate.				
Rank F – Low: Some aspects of the geological environment may be favourable but are limited in extent. Few if any occurrences are known. Low probability that undiscovered deposits are present.				Diamonds

Rank G – Very Low: Geologic environment is unfavourable. No occurrences are known. Very low probability that undiscovered deposits are present.				
Rank H – Not Assessed: Deposit types unknown, overlooked, beyond the scope of the assessment, or not worth mentioning at the time the assessment was done. A higher rating could be assigned during future assessments.				SEDEX, sandstone-hosted lead deposits, Irish-type Zn-Pb deposits, carbonate-hosted Cu-Pb-Zn deposits (Kipushi type), and Broken Hill-type Pb-Zn deposits Unconventional resources Granular resources (e.g. sand and gravel)
The criteria for assessing mineral potential follows the Geological Survey of Canada's Mineral and Energy Resource assessment rating scale (Scoates et al., 1986).				

CONCLUSIONS

The geological setting of the Ka´a´gee Tu area is similar to the Pine Point area that contains world class MVT-type deposits. Important similarities include Middle Devonian rocks deposited on the Presqu'ile barrier, proximity to major basement structures and the development of hydrothermal dolomite. In the Pine Point area, Middle Devonian rocks and lead-zinc mineralization are locally exposed at surface simplifying mineral exploration and mining operations. In the Ka´a´gee Tu area, favourable stratigraphic units are concealed by Upper Devonian rocks making base metal exploration more difficult. Limited exploration undertaken in the late 1970s and early 1980s detected minor concentrations of lead and zinc in widely-spaced drill holes.

The mineral potential of this area is moderate to high for MVT deposits. Unlike many frontier areas of the NWT, the study area has some supporting infrastructure including access to road and rail networks. The short-term outlook for base metal exploration is probably low although it could be upgraded with future improvements in exploration technology. Advances in exploration technology are likely to be driven by the petroleum industry that has greater financial resources to devote to the development of subsurface imaging technology.

Archean basement rocks along the eastern edge of the study area are favourable for diamondiferous kimberlite intrusions, although no public data is available to further refine the mineral potential assessment. Exploration outside of the study area has also detected diamondiferous kimberlite that intrudes basement rocks of the Hottah terrane. The ages of kimberlites in adjacent areas suggest that intrusions in the study area have the potential to outcrop through regional Devonian units making them detectable by surficial mineral surveys. The study area is considered to have a low to moderate potential for diamonds with a low level of certainty.

Information Gaps

- traditional knowledge on landscape features, minerals, fossils and lapidary resources
- compilation of geo-tourism potential within candidate area
- surficial geology mapping
- surficial geochemical information
- assessment of granular resources including projected future demand
- confirmation of interpreted basement domains beneath study area

Recommendations

The MVT deposit potential of the study area is well known from recent regional metallogenic studies. Under the current rating system, the mineral potential of the study area can only be increased by recognizing mineralization or significant deposits. As the favourable horizon is located at depth, it is unlikely that Phase II studies will be able to locate occurrences and increase the mineral potential rating. Mineral prospectivity mapping has been previously undertaken and further predictive mapping would likely use similar base datasets and come to similar conclusions. As a result, little additional work is required to increase the confidence in the assessment of MVT deposits.

Instead Phase II studies should concentrate on evaluating the diamond potential of the region. As cover rocks are of Devonian age and kimberlite intrusions of the adjacent regions are potentially of Cretaceous or Tertiary age, it is possible that kimberlites may be exposed at the bedrock surface. Regional till sampling should be undertaken to evaluate the diamond potential. As there is little associated cost, till samples should also be analyzed for metallic elements. Studies on the basement rocks of the area could also be undertaken if samples are available from hydrocarbon wells that terminate in basement.

A major data gap for the area is the amount of surficial mapping. Surficial mapping should be undertaken in conjunction with regional till sampling. This information can be used to estimate the volume of granular material in the regional area to determine if establishment of protected areas will affect supplies of granular material in the region. The quality and quantity of granular resources should be further quantified so they can be considered in land use planning.

No attempt was made to catalog natural features, lapidary resources or fossil collecting areas to undertake a geo-tourism assessment. Phase II investigations should undertake these tasks and could be supported by traditional knowledge studies.

As a final recommendation, planners are also encouraged to consider the far future implications of land use planning decisions. At the time of discovery over a hundred years ago, mineral resources in the Pine Point area were considered to be of little value because of their remote location. The area subsequently developed into a world class mining camp. Recently, proposals have been announced to exploit buried resources in the GSR area showing the gradual shift to subsurface exploitation. Although from our current perspective the discovery of resources in the deep subsurface seems remote, the future value of these areas could be greater.

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