GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7568

Surficial geology field observations and photographs for the Breynat Point map area (NTS 85-B/15)

Oviatt, N.M., Paulen, R.C. and Rufiange, E.C.

2014

Natural Resources Canada | Ressources naturelles Canada

Canada

GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7568

Surficial geology field observations and photographs for the Breynat Point map area (NTS 85-B/15)

N.M. Oviatt[1], R.C. Paulen[2], and E.C. Rufiange[3]

[1] Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta
[2] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario
[3] Department of Earth Sciences, University of Ottawa, Ottawa, Ontario

2014

doi:10.4095/293452

This publication is available for free download through GEOSCAN (http://geoscan.ess.nrcan.gc.ca/)

Contribution to the Geo-Mapping for Minerals and Energy Program (GEM) 2008-2013

Recommended citation
Oviatt, N.M., Paulen, R.C., and Rufiange, E.C., 2014. Surficial geology field observations and photographs for the Breynat Point map area (NTS 85-B/15); Geological Survey of Canada, Open File 7568. doi:10.4095/293452

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

As part of the Geological Survey of Canada's Geo-mapping for Energy and Minerals (GEM) Program, surficial mapping was undertaken in the Breynat Point map area, National Topographic System (NTS) 85B/15. The Pine Point region is of very low relief and characterized by black spruce bogs with local relief not exceeding 20 m. During Wisconsin time, the Breynat Point map sheet was actively and continuously glaciated by the Laurentide Ice Sheet. Multiple till units were observed in the open pits, however only the uppermost unit was mapped at surface. The map area was completely inundated by proglacial Lake McConnell during deglaciation and glaciolacustrine sediments are the dominant materials that occur as beach ridges and littoral sediments. Beach ridges were reworked to form eolian dune ridges up to 15 m high. Raised strandlines formed by earlier phases of Great Slave Lake mark the former isostatic rebound of the land surface. Organic deposits are extensive with mature peatlands and fens, which are underlain by discontinuous permafrost with active thermokarst. Abandoned open pits and waste piles pockmark the former Pine Point mining district. This open file is to augment information available from Canadian Geoscience Map 114, and provides additional information on field observations made during the production of this map.

INTRODUCTION

The Pine Point mining district is located on the south shore of Great Slave Lake, Northwest Territories, in the Great Slave Plain physiographic region of the Western Interior Plains (Bostock, 1970). The former mining district is approximately 180 km due south of Yellowknife, in the Buffalo Lake topographic map sheet (NTS 85B) and approximately 50 km east of the town of Hay River. The Buffalo River flows north into Great Slave Lake on the western side of the study area. Black spruce bogs characterize the area and local relief does not exceed 15 m (Lemmen et al., 1994). The Pine Point mine site and open pits can be accessed via Highways 5 and 6, and in the summer by mine roads using a truck or all-terrain vehicle.

The objective of this mapping activity was to describe and record the surficial materials in the area and to document their distribution. The construction of the map (Oviatt and

Paulen, 2013) was completed by interpretation of 1:25,000 aerial photographs and ground-truthing was carried out over the 2011 summer field season (Figure 1).

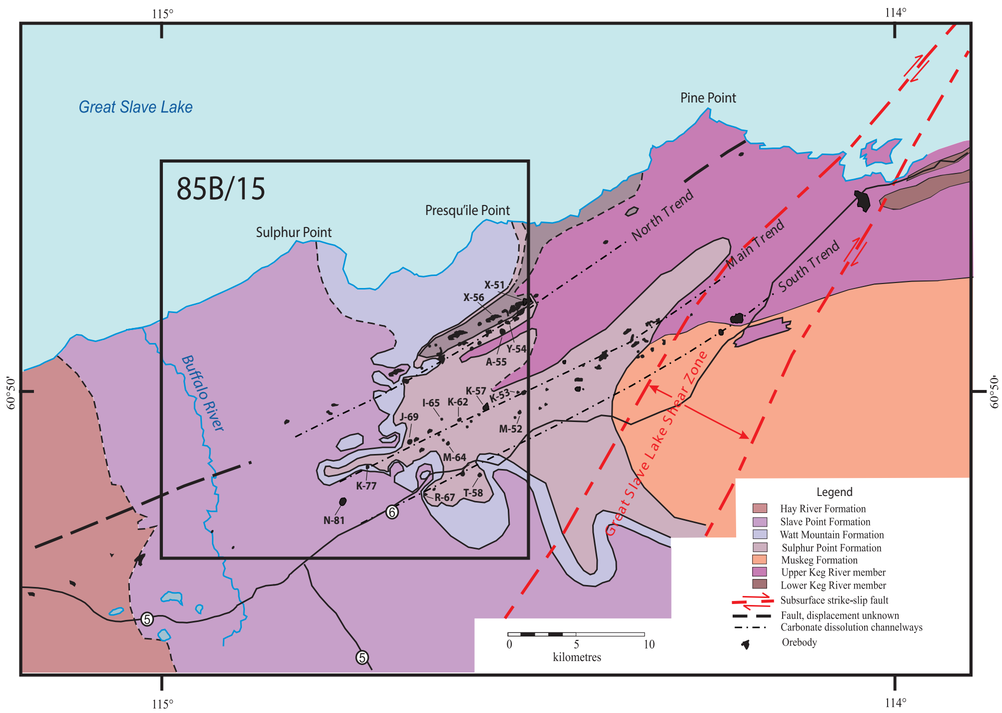

Figure 1. Bedrock geology map of the Pine Point area (modified from Hannigan, 2007) showing the three orebody trends, major structures and lithological units; open pits visited for ground-truthing are indicated. The large box outlines Breynat Point (NTS 85B/15).

Bedrock Geology

The bedrock of the Pine Point area consists of 350 to 600 m of Ordovician to Devonian units that overlie crystalline basement rocks of the Archean and Proterozoic (Skall, 1975; Kyle, 1977; Rhodes et al., 1984). More specifically, the deposits are hosted by, or proximal to, the Presqu'ile barrier which is a reef-like complex (200 m at its thickest point) that separates the deep marine rocks to the north from the shallow marine rocks to the south (Rhodes et al., 1984; Hannigan, 2007). The Presqu'ile barrier consists of the Upper Keg River and Sulphur Point formations. The Upper Keg River Formation includes the lower two-thirds of the barrier and consists of flat, lensoidal beds of carbonate sandstones and mudstones and fine, dense, grey-brown to buff brown dolomite with abundant carbonaceous fossils (Skall, 1975; Hannigan, 2007). The overlying Sulphur Point Formation consists of a build-up of bioherms, bioclastic limestones and carbonate sandstones (Rhodes et al., 1984; Hannigan, 2007) and has undergone alteration into a coarse crystalline, vuggy dolomite known as Presqu'ile dolomite which is the host of the majority of the ore bodies (Skall, 1975; Hannigan, 2007). Karstification was the primary control for ore deposition in the area (Rhodes et al., 1984; Hannigan, 2007).

The Pine Point district covers an area of approximately 1600 km^2 and consists of 100 drill-defined orebodies that average 2% Pb and 6.2% Zn (Hannigan, 2007). The total geological resource (produced and remaining proven resource) is estimated to be 95.4 Mt (Hannigan, 2007), however the mine site closed in 1988 due to dropping market prices for Pb and Zn and rising mining costs (Hannigan, 2007).

Surficial Geology

The Pine Point area has an extensive Quaternary record. There is evidence of at least three directions of ice flow that were recorded from striae on bedrock surfaces uncovered during past mining activity (Oviatt et al., 2013). A study by Rice et al. (2013) determined there are four visually and characteristically distinctive till units in the Pine Point area. There was no evidence that these till units were from different glacial events but rather that they likely record changes (i.e., provenance) in the western sector of the Laurentide Ice Sheet (LIS) (Rice et al., 2013). The Pine Point area was glaciated throughout the entire Wisconsin; during the Middle Wisconsin, the margin of the LIS was to the north and west of Pine Point (Rice et al., 2013) as opposed to near the margin of the Canadian Shield, to the east of Pine Point (Dyke et al., 2002). The Laurentide Ice Sheet readvanced into the Western Canada Sedimentary Basin at the onset of the Late Wisconsin (Dyke and Prest, 1987).

During the last glacial maximum, approximately 18 ^{14}C ka BP, the area was covered by ice from the Keewatin Sector of the LIS (Dyke and Prest, 1987; Dyke, 2004). The western margin of the LIS had coalesced with the eastern margin of the Cordilleran Ice Sheet (CIS) covering most of Canada in a sheet of ice (Jackson et al., 1999; Bednarski and Smith, 2007). Deglaciation began in earnest at approximately 14 ^{14}C ka BP (Dyke and Prest, 1987) beginning with the separation of the CIS and the LIS. Complete separation of these two ice sheets occurred at approximately 12.5 ^{14}C ka and deglaciation began affecting the Pine Point area at approximately 10.5 ^{14}C ka BP (Dyke and Dredge, 1989; Dyke, 2004). Deglaciation of the study area was an easterly retreat of the LIS margin and the formation of glacial Lake McConnell (Lemmen et al., 1994; Dyke, 2004). The geomorphology of the Pine Point region is the result of glaciolacustrine processes associated with glacial Lake McConnell.

Glacial Lake McConnell was an extensive body of water that occupied the basins of Great Bear, Great Slave and Athabasca lakes. This proglacial lake was one of the largest glacial lakes to exist in Canada (Lemmen et al., 1994) covering approximately 215,000 km^2 (Fig. 2). The lake existed in three different stages from 11.8 to 8.3 ^{14}C ka BP (Smith, 1994). These stages were named the Hare Indian phase, the Great Bear phase and the Mackenzie phase by Smith (1994). The Mackenzie phase was the most extensive and it directly affected the area of this study. Glacial Lake McConnell formed in the northwestern arm of Great Bear Lake, and extended southwards towards Great Slave Lake when isostatic loading and ice-dams allowed water levels to breach the current 219 m drainage divide between the two basins (Craig, 1965; Smith, 1994; Lemmen et al., 1994). The highest beach ridges in the Pine Point area occur south of Hay River at 295 m above sea level (ASL).

METHODS

Initial interpretation of surficial geology was made on 1:25,000 scale aerial photographs (Natural Resources Canada, flight lines A23440-2 to 16, A23368-79 to 88, A23371-52 to 67, A23372-130 to 146, A23373-44 to 59, A23373-170 to 187, and A23374-219 to 233). These areas were then field-checked with till sampling locations, mapping verification sites and at natural and anthropogenic exposures. Access to the northern section of the map-sheet was greatly restricted by extensive fens and wetlands. A total of 135 field stations were recorded and the data from these sites are available in Appendix A. The final station density across the map-area (excluding Great Slave Lake) was approximately 1 station per 4 km^2. At each station, a hole was dug or a Dutch Auger was inserted to a depth of at least 1 m. A description of the unit(s) present was recorded and photos were taken. Site photos are available in Appendix B. The final map was produced at a scale of 1:50,000 and published as Canadian Geoscience Map 114 by the Geological Survey of Canada (Oviatt and Paulen, 2013).

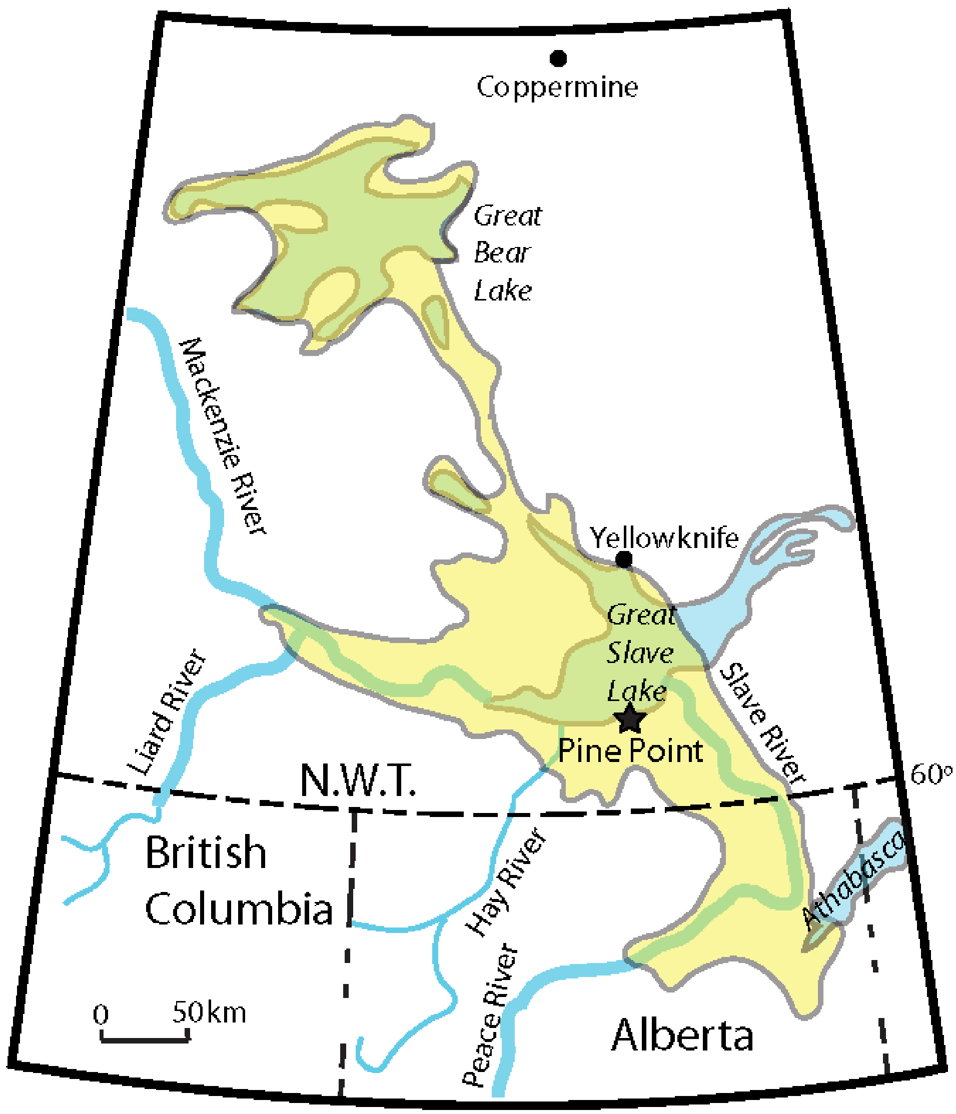

Figure 2. The Mackenzie phase of glacial Lake McConnell in yellow, superimposed on modern drainage basins (modified from Craig (1965) and Lemmen et al., (1994)). The Pine Point region was inundated by this phase. The approximate location of the western margin of the LIS would have been along the eastern edge of glacial Lake McConnell, between Athabasca and Great Slave Lake (Smith, 1994).

There are eight columns describing the surficial mapping ground-truthing sites:

Site Number: mapping observation station identifier
Pit: mine identification number for each open pit, of the former Pine Point Mine
Easting: UTM coordinates, Datum NAD 87, UTM Zone 11
Northing: UTM coordinates, Datum NAD 87, UTM Zone 11
Surficial Unit: surficial geology map unit, refer to the surficial map legend for Canadian Geoscience Map 114 (Oviatt and Paulen, 2013)
Photos: indicates whether a photo or not, was taken at this station (number of photos in brackets)
Comments: short description of the site or surficial geomorphology and geology.

BEDROCK AND SURFICIAL MATERIALS

The map units in the 85B/15 area are as follows: Bedrock (R), Glacial sediments (T, Tb), Glaciolacustrine sediments (GL, GLr, GLn), Lacustrine sediments (L, Lr, Ln), Alluvial sediments (A, Ap, Af, At), Eolian sediments (E, Er), Organic deposits (O, Owf, Owb), Colluvial (C), and Anthropogenic deposits (H). The most extensive units in the map area are glaciolacustrine sediments deposited by glacial Lake McConnell.

Bedrock (map unit R)

Dolomitized limestone bedrock outcrops at the surface at the bottom of a stream bed in the center of the map sheet. Bedrock is also exposed at the base and bedrock benches of some of the former mine open pits.

Glacial Sediments (map units T, Tv, Tb)

Glacial sediments (till) occur as blanket deposits (Tb) in small patches at slightly higher elevations. These units are typically capped by a boulder or cobble lag produced by glacial Lake McConnell. Glacial sediments cover approximately 2% of the surficial map area and typically occur within ridged beach sediment units. The upper contact between till and organic units was usually marked by a thin sand or gravel layer. The upper contact between till and beach ridges were gradational with the silt and clay content of well-sorted sand and gravel increasing towards the contact. Till veneer (Tv; generally <2 m thick) occurs in close proximity to the small area of bedrock outcrop, mentioned above. The till at the surface is an unsorted glacial diamicton (T), with a 10-15% clast content of mixed lithologies and contains an average of 8% inorganic carbon and 0.3% organic carbon (Oviatt et al., 2013). Till at the surface has a sandy-silt matrix containing an average of 14% clay, 50% silt and 36% sand with an olive-brown color when freshly exposed. Till in the area is predominately light-grey in colour when dry (Oviatt, 2013). Some sandier, light-brown tills were observed. Joints within fissile till were occasionally iron and manganese stained. Precambrian shield and Paleozoic carbonate clasts were the dominant lithologies in till (Rice et al., 2013) and were generally subrounded to subangular. Clasts within the till were usually faceted and striated and ranged in size from granules to large boulders (> 1 m).

Glaciolacustrine Sediments (map units GL, GLr, GLn)

Glaciolacustrine deposits are mapped as beach sediments (GLr), nearshore and littoral deposits (GLn) and undifferentiated (GL). Beach sediments occur as ridges throughout the map sheet. Well-developed beach ridges within the 85B/15 map sheet occur at 190 m and 220 m ASL. Beach ridges are characterized by well-sorted, medium grained sand ranging in thickness from 15 cm to over 2 m with a boulder lag. A typical beach ridge consists of: (1) cobble lag, (2) 10-15 cm sand and gravel, (3) ~ 15 cm coarse sand and, (4) and over 40 cm of coarse sand with silt and clay. These ridges contain fragments of clasts that originated on the Canadian Shield indicating that these beaches are remnants of winnowed till. They commonly overlie unmodified till. Beach sediments cover approximately 40% of the map area and occur in ridges that are sub-parallel to the current shoreline of Great Slave Lake.

Nearshore and littoral deposits usually occur in close proximity to beach ridges. These deposits are characterized by moderately-sorted open framework sand and gravel that is commonly overlain by a cobble lag. Nearshore and littoral deposits are typically 70 cm to >1 m thick and cover approximately 10 % of the map sheet. Glaciolacustrine deposits are composed mainly of silt and clay and range from 0.1 to 1.2 m in the 85B/15 area. The upper contacts of these deposits were occasionally marked with interbeds of fine sand with silt and clay. These deposits (GL) occur at an elevation of approximately 200 to 215 m ASL and cover approximately 5% of the map sheet.

Lacustrine Sediments (map units L, Lr, Ln)

Lacustrine sediments occur exclusively along the shores of present day Great Slave Lake. Beach sediments (Lr) consist of fine to coarse and gravel. These sediments occur as ridges between 1 to 1.5 m high. Littoral and nearshore sediments (Ln) occur as fine sand to pebble material with a well-sorted cobble lag. These units occur at elevations between 150 and 160 m ASL.

Alluvium Sediments (map units A, Ap, At, and Af)

Alluvial sediments occur along all rivers in the area particularly along the present day Buffalo River. Floodplain (Ap) deposits are described as sorted gravel, sand and silt that occur close to river level forming active floodplains associated with the Buffalo River. Alluvial terrace (At) deposits occur along the banks of the Buffalo River and consist mainly of sand and gravel. Alluvial fan (Af) deposits are poorly sorted sand and gravel and are associated with small creeks and streams that are scattered throughout the map sheet.

Eolian Sediments (map units E, Er)

Eolian sediments occur throughout the map sheet as large (10 m) parabolic dunes and as smaller (1-2 m) longitudinal dunes. The reworking of the beach sediments deposited by glacial Lake McConnell produced these dunes. The parabolic dunes are composed of medium to fine-grained sand that contain planar laminations and are rhythmically bedded. The corrected OSL dates for the sand samples collected at a dune on the south edge of the map sheet (261 m ASL) were determined to be 11.1 ± 1.1 ka and 10.5 ± 0.9 ka, respectively (Oviatt, 2013; Oviatt and Paulen, 2013). These ages were determined by single aliquot regeneration protocol described in Lian et al., (2002).

Organic Deposits (O, Owf, Owb)

Organic deposits are extensive throughout the region; they consist of peat bogs (Owb) and poorly drained fens (Owf). Bogs are characterized by the presence of black spruce trees and extensive sphagnum moss. Fens are composed of sparsely-treed peatland with numerous ponds. These ponds are often in-filled features associated with thermokarst terrain. Both of these deposits can be locally underlain by shallow permafrost or ground ice. Bogs and fens commonly overlie poorly-drained glacial till or glaciolacustrine sediments and occupy 30% of the surficial map area. Organic deposits were greater than 2 m thick in some places.

Colluvial Deposits (map unit C):

Colluvium deposits consist of deposits created by mass movement of debris along the incised river valley of the Buffalo River. They are characterized by poorly-sorted material comprising of the upper sedimentary units occurring in the upper part of the river valley.

Anthropogenic Deposits (map unit H)

Anthropogenic deposits occur as mine waste piles, settling ponds and reworked overburden associated with the Pine Point mine operation (1964- 1988). There are 17 open pits in the map sheet each with an associated mine waste pile that can exceed 20 m high, providing the most extensive topographic relief in the area.

ACKNOWLEDGMENTS

Surficial mapping was undertaken by the Geomapping for Energy and Minerals (GEM) Program in conjunction with Tamerlane Ventures Incorporated and Teck Resources Limited as partial requirement for a M.Sc. thesis at the University of Alberta. Ethusiastic support and field assistance was provided by J. Rice (Brock University), M.B. McClenaghan (GSC Ottawa) and S. Gleeson (University of Alberta). Digital topographic and satellite imagery was provided by T. Lynds (GSC Atlantic). Logistical support was provided by M. Francis (GSC Calgary). This report benefitted from a review from D. Kerr (GSC Ottawa), who provided constructive edits and suggestions.

REFERENCES

Bednarski, J.M., and Smith, I.R., 2007. Laurentide and montane glaciation along the Rocky Mountain Foothills of northeastern British Columbia; Canadian Journal of Earth Sciences, v. 44, p. 445-457.

Bostock, H.S., 1970. Physiographic regions of Canada; Geological Survey of Canada, Map 1254A, scale 1:5,000,000.

Craig, B.G., 1965. Glacial Lake McConnell, and the surficial geology of parts of Slave River and Redstone River map-areas, District of Mackenzie; Geological Survey of Canada Bulletin 122, p. 1-33.

Dyke, A.S. 2004. An outline of North American deglaciation with emphasis on central and northern Canada; *in* Quaternary Glaciations - Extent and Chronology, Part II. North America, (ed.) J. Ehlers and P.L. Gibbard; Elsevier B.V., Amsterdam, Development in Quaternary Science Series, Vol. 2: 373-424.

Dyke, A.S., and Prest, V.K., 1987. Late Wisconsin and Holocene history of the Laurentide Ice Sheet; Géographie physique et Quaternaire, v. 41, p. 237-263.

Dyke, A.S., and Dredge, L.A., 1989. Quaternary geology of the northwestern Canadian Shield; *in* Chapter 3 of Quaternary Geology of Canada and Greenland, Geological Survey of Canada, (ed.) R.J. Fulton, R.J.; Geology of Canada, no. 1 (also Geological Society of America, The Geology of North America, v. K-1), p. 189-214.

Dyke, A.S., Andrews, J.T., Clark, P.U., England, J.H., Miller, G.H., Shaw, J. and Veillette, J.J. 2002. The Laurentide and Innuitian ice sheets during the Last Glacial Maximum; Quaternary Science Reviews, v. 21, p. 9-31.

Hannigan, P., 2007. Metallogeny of the Pine Point Mississippi Valley-Type zinc- lead district, southern Northwest Territories; *in* Mineral Deposits of Canada: A Synthesis of Major Deposit-Types, District Metallogeny, the Evolution of Geological Provinces, and Exploration Methods, (ed.) W.D. Goodfellow; Geological Association of Canada, Mineral Deposits Division, Special Publication No. 5, p. 609-632.

Jackson, L.E., Jr., Phillips, F.M. and Little, E.C., 1999. Cosmogenic ^{36}Cl dating of the maximum limit of the Laurentide Ice Sheet in southwestern Alberta; Canadian Journal of Earth Sciences, v. 36, p. 1347-1356.

Kyle, J.R., 1977. Development of sulphide hosting structures and mineralization, Pine Point, Northwest Territories; Ph.D. thesis, University of Western Ontario, 226 p.

Lemmen, D.S., Duk-Rodkin, A., and Bednarski, J.M., 1994. Late glacial drainage systems along the northwestern margin of the Laurentide Ice Sheet; Quaternary Science Reviews, v. 13, p. 805-828.

Lian, O.B., Huntley, D.J., and Wolfe, S.A., 2002. Optical dating of eaolian dune sand from the Canadian prairies; Géographie physique et Quaternaire, v. 56, p. 191-202.

Oviatt, N.M. 2013. Characterization of indicator minerals and till geochemical dispersal patterns associated with the Pine Point Pb-Zn Mississippi Valley-type deposits Northwest Territories, Canada; MSc. Thesis, Earth and Atmospheric Sciences, University of Alberta, Edmonton.

Oviatt, N.M. and Paulen, R.C. 2013. Surficial geology, Breynat Point NTS 85-B/15, Northwest Territories; Geological Survey of Canada, Canadian Geoscience Map 114 (preliminary), scale 1:50,000.

Oviatt, N.M., McClenaghan, M.B., Paulen, R.C., and Gleeson, S.A., 2013. Till geochemical signatures of the Pine Point Pb- Zn Mississippi Valley-type district, Northwest Territories; Geological Survey of Canada, Open File 7320. doi:10.4095/292906

Rice, J.M., Paulen, R.C., Menzies, J.M., McClenaghan, M.B. and Oviatt, N.M., 2013. Glacial stratigraphy of the Pine Point Pb-Zn mine site, Northwest Territories. Geological Survey of Canada, Current Research Paper 2013-5, 17 p.

Rhodes, D., Lantos, E.A., Lantos, J.A., Webb, R.J., Owens, D.C., 1984. Pine Point orebodies and their relationship to the stratigraphy, structure, dolomitization, and karstification of the middle Devonian Barrier complex; Economic Geology, v. 79, p. 991-1055.

Skall, H., 1975. The paleoenvironment of the Pine Point lead-zinc district; Economic Geology, v. 70, p. 22-47.

Smith, D.G. 1994. Glacial Lake McConnell: paleogeography, age, duration and associated river deltas, Mackenzie River basin, western Canada; Quaternary Science Reviews, v. 13, p. 829-843.