Descriptive Notes

The Sulphur Bay (NTS 85G) map area is located along the western margin of Great Slave Lake extending from the entrance of the North Arm south towards the outlet of the Mackenzie River. The region is characterized by low relief, subdued glacial features, and abundant bog and fen. The map area is situated within the sporadic discontinuous permafrost zone (Heginbottom et al., 1995) and thermokarst terrain in areas of bog and fen is extensive. Topography is largely controlled by flat-lying to gently westward-inclined Lower and Middle Devonian carbonate platform bedrock (Okulitch, 2006). In the northern portion of the map, the unconformity between Paleozoic strata and the Precambrian Canadian Shield occurs about 10 km offshore (under Great Slave Lake). Outcrops of Lower Devonian argillaceous rocks (Mirage Point Formation) to Middle Devonian Elk Point Group are exposed where the glacial sediment cover was eroded and removed by glacial Lake McConnell. Karst morphology, including prominent sinkholes, is common, and most frequently occurs in areas underlain by the Middle Devonian Lonely Bay Formation.

Glacial flow history is reflected by different sets of streamlined glacial landforms. In the southern part of the map area, relict bedrock sculpting by earlier northwest flowing ice is preserved. An older regional northwest flow was also documented south of the map area at Pine Point (Oviatt et al., 2015; McClenaghan et al., 2018). The land area in the map is predominantly overprinted by southwestward-trending streamlined glacial landforms, which in some areas have the characteristic high elongation ratios of mega-scale glacial lineations (MSGLs), indicative of ice streaming. These landforms are commonly less than 15 m wide, but often extend for several kilometres down flow. A thick (>20 m) stack of thrusted carbonate till, commonly with steeply dipping clasts, formed at Moraine Point. This unusual landform likely is the product of intense abrasion of softer Paleozoic rocks by an abrading ice stream with Canadian Shield subglacial debris, as has also been observed along Paleozoic-Shield boundary zones elsewhere in Canada (Bukhari et al., 2021). This late southwest ice flow has also been documented around Yellowknife (Kerr, 2006) and in the upper Mackenzie River valley (Paulen et al., 2019a).

During deglaciation, ice in the isostatically-depressed Great Slave Lake basin retreated in contact with a large proglacial lake, that eventually merged with basins north and south of this map area to form glacial Lake McConnell (Craig, 1965; Lemmen et al., 1994; Smith, 1994). Successive, sometimes discontinuous, flights of prominent (<2 m high) subparallel beach ridges, comprising open-framework pebbles and cobbles in a sand matrix and discontinuous, thin (<2 m) sandy nearshore lake sediments, document the regression of glacial Lake McConnell and its later proto-Great Slave Lake extents, well into the Holocene. Elsewhere, till was winnowed to produce discontinuous, thin (<0.5 m), cobble and boulder surface lags. Icebergs calved from the retreating ice margin created abundant southeast-northwest-trending iceberg scours at lower elevations. During the Holocene, glacioisostatic uplift resulted in the continuous decanting of glacial Lake McConnell down the Mackenzie River. Beach ridges transitioned from larger berms (<2 m) at higher elevations, originally deposited by katabatic wind-driven waves, into numerous smaller berms (<1 m) formed during the regression of proto-Great Slave Lake as the postglacial isostatic uplift continued (O'Neill et al., 2019).

Elevated water tables, formed due to flat and relatively impermeable bedrock and till cover at surface, have caused extensive bogs and fens to develop. The map area lies within the discontinuous permafrost zone (Heginbottom et al., 1995) and thermokarst ponds have formed over much of the bog-covered map area.

Till samples were collected at eight sites for kimberlite indicator minerals (KIMs), magmatic and massive sulphide minerals (MMSIM), and matrix analyses (Paulen et al., 2019b). Sample and chemistry results indicate elevated counts of KIMs that are most similar to the Drybones Bay and Mud Lake kimberlites, >50 km to the northeast on the eastern shore of Great Slave Lake (Smith et al., 2021). At Gypsum Point, a beautiful composite pyrope-chrome diopside grain was recovered from an argillaceous-rich till sample (sample 18-PTA-011; Fig. 1).

Finally, no attempts were made to "edge-match" surficial geology polygons along the northern boundary of this map sheet with the adjoining Yellowknife and Hearne Lake remote predictive surficial map (CGM 200; Stevens et al., 2017). These remote predictive surficial geology maps are constructed largely from mixed manual and automated interpretations of LANDSAT data, and are typically uninformed by aerial photograph interpretation, and have no or very limited ground truthing. We consider our field- and aerial photograph-based interpretations to be a more accurate representation of the regional surficial geology.

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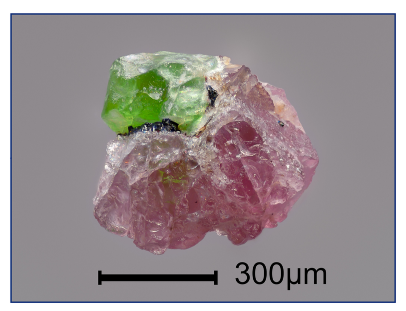


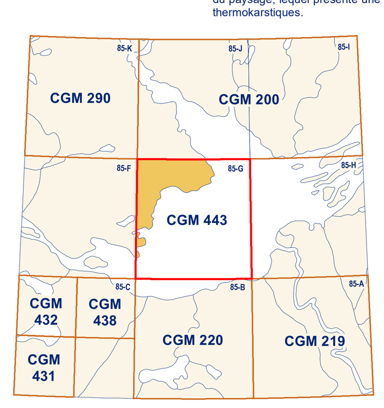
Figure 1. A large composite kimberlite indicator mineral grain consisting of pyrope (purple) and chrome diopside (green), recovered from a till sample at Gypsum Point (18-PTA-011; Smith et al., 2021). Photomicrograph by Michael Bainbridge.

Abstract

The Sulphur Bay map sheet is a low-relief terrain underlain by lower- to middle-Devonian dolostone and limestone. A thin (<4 m thick) Laurentide Ice Sheet-derived glacial sediment cover drapes most of the landscape, except for bedrock outcrops exposed near Great Slave Lake. Relict glacial landforms record an older northwest ice flow across the region. These are strongly overprinted by subsequent west-southwest-oriented flutings and mega-scale glacial lineations formed during deglaciation. As ice retreated, the entire map area became inundated by glacial Lake McConnell and then subsequently by the expanded postglacial Great Slave Lake. This produced a discontinuous, coarse winnowed surface lag over higher terrain and thin sheets of glaciolacustrine nearshore sands over lower-lying regions. Abundant iceberg furrows occur throughout the map area. Bogs and fens have formed over much of the landscape and display extensive thermokarst.

Résumé

La région cartographique de Sulphur Bay présente un terrain peu accidenté au sous-sol formé de dolomie et de calcaire du Dévonien inférieur et moyen. Une mince couche (<4 m d'épaisseur) de sédiments glaciaires associés à l'Inlandsis laurentidien recouvre la majeure partie du paysage, à l'exception d'affleurements rocheux situés à proximité du Grand lac des Esclaves. Des reliefs glaciaires reliques témoignent d'un écoulement glaciaire plus ancien de direction nord-ouest dans l'ensemble de la région. Des cannelures et des linéations glaciaires à grande échelle de direction sud-ouest, formées ultérieurement lors de la déglaciation, se superposent à ces reliefs de façon très marquée. Au fur et à mesure du retrait glaciaire, l'ensemble de la région cartographique a été ennoyée par le Lac glaciaire McConnell, puis subséquemment par la phase postglaciaire étendue du Grand lac des Esclaves. Cet ennoyage a entraîné la formation par vannage d'un résidu de déflation grossier qui s'étend de manière discontinue aux terrains plus élevés et déposé de minces nappes de sables littoraux glaciolacustres dans les régions plus basses. De nombreux sillons résultant d'un affouillement par des icebergs parsèment l'ensemble de la région cartographique. Des tourbières ombrotrophes et minérotrophes se sont formées dans la majeure partie du paysage, lequel présente une abondance de formes thermokarstiques.



National Topographic System reference and index to adjoining published Geological Survey of Canada maps

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Natural Resources Canada / Ressources naturelles Canada

CANADIAN GEOSCIENCE MAP 443

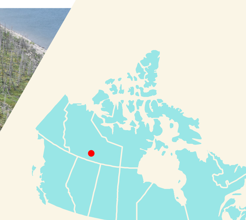
SURFICIAL GEOLOGY

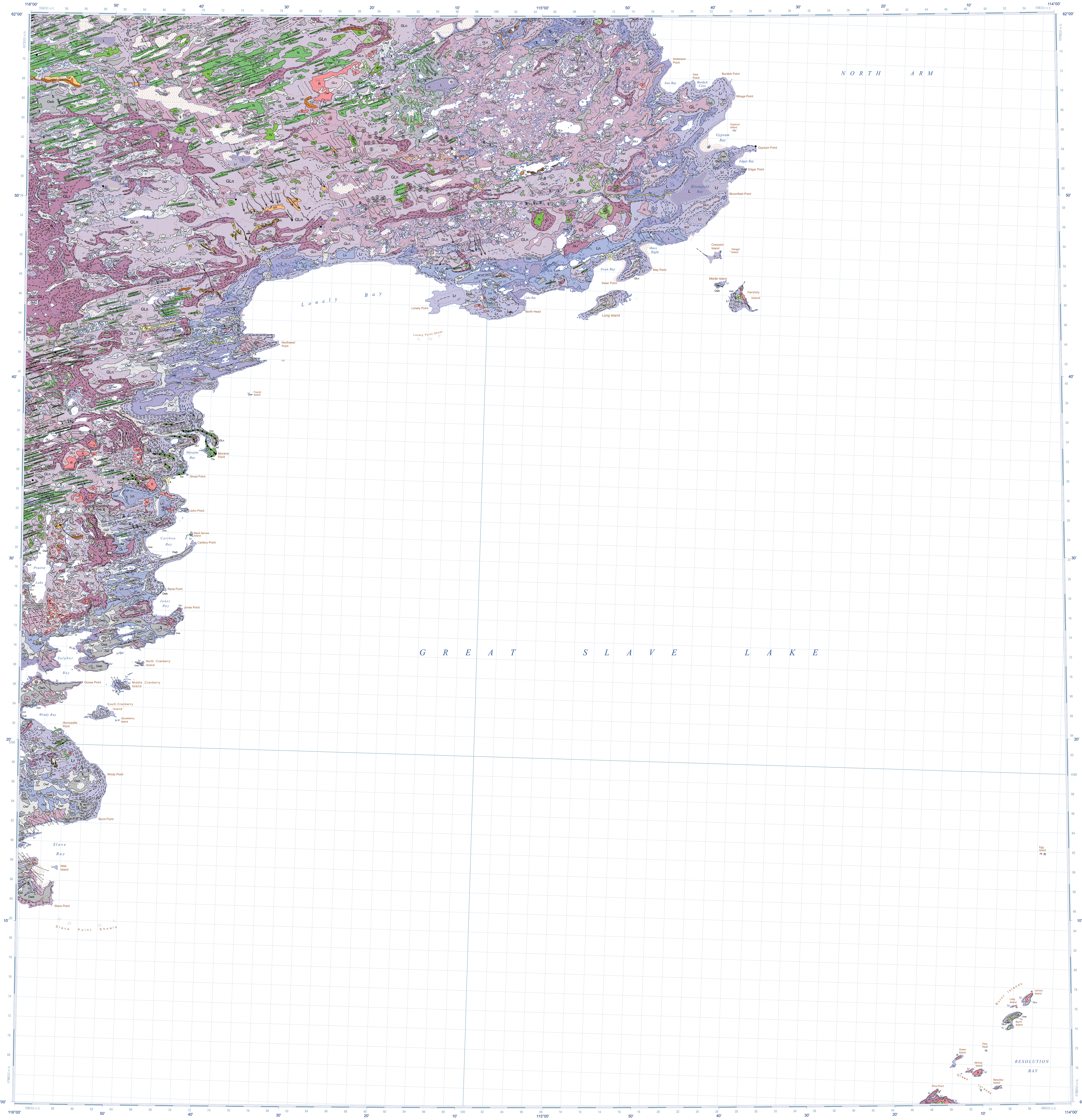
SULPHUR BAY

Western Great Slave Lake, Northwest Territories

NTS 85-G

1:125 000





QUATERNARY

POST LAST GLACIATION

NONGLACIAL ENVIRONMENT

ORGANIC DEPOSITS: peat and muck; formed by the accumulation of plant materials in various stages of decomposition; occur as low-relief, wet terrain over poorly drained substrates; average 1 to 3 m thick, and locally up to 5 m thick.

Owf — **Fen deposits:** semiopen peatlands derived from sedges and partially decayed shrubs in a eutrophic environment; mineral-rich water table persists seasonally at surface; commonly with ribbed patterns transverse to drainage; generally covered with low shrubs and grasses; locally affected by permafrost conditions; may contain areas with extensive thermokarst (as indicated).

Owb — **Bog deposits:** *Sphagnum* or forest peat formed in an ombrotrophic environment; water table close to surface; may be treeless or sparsely treed; may contain areas with extensive thermokarst (as indicated).

O — **Undifferentiated deposits:** undifferentiated bog and fen deposits; associated with isolated patches of organic-material accumulation and may include organic detritus in small intermittent drainages.

NONGLACIAL AND PROGLACIAL ENVIRONMENTS

EOLIAN SEDIMENTS: medium to fine sand; wind deposited; sediments derived from glaciofluvial and glaciolacustrine sources; well sorted; typically massive.

Er — **Dunes:** parabolic and linear morphologies; >2 m thick; eolian sediment in areas between dunes ridges may be thin or absent.

E — **Undifferentiated sediments:** isolated patches, or interdune areas; variable thicknesses.

ALLUVIAL SEDIMENTS: gravel, sand, silt, and organic detritus deposited by flowing water; sorted; commonly stratified; variable thickness.

Ap — **Floodplain sediments:** deposited in active floodplains close to river level; includes meander channels, scroll bars, overbank sediments, and oxbow lakes; low relief; >1 m thick.

A — **Undifferentiated sediments:** undifferentiated fluvial deposits; variable thickness.

LACUSTRINE SEDIMENTS: cobble gravel, sand, silt, and clay, sometimes intermixed with organic detritus; deposited around modern lake basins during former or recent fluctuations in lake level; variable thickness.

Lr — **Beach sediments:** gravel, sand, and silt, often with cobble and boulder lags on beaches developed along Great Slave Lake; prominent ridges developed by storm surges and ice-push ramparts, often with abundant driftwood; weakly stratified; ≤2 m high.

Ln — **Nearshore sediments:** well sorted gravel, sand, and silt; deposited in littoral settings; may include small beach ridges (<1 m high) and lag deposits; <2 m thick.

L — **Undifferentiated sediments:** undifferentiated lacustrine sediments; may be locally overlain by a thin (<1 m) layer of organic sediments; <2 m thick.

POSTGLACIAL OR LATE WISCONSIN

PROGLACIAL AND GLACIAL ENVIRONMENTS

GLACIOLACUSTRINE SEDIMENTS: gravel, sand, silt, and clay deposited in proglacial lakes along the margin of the retreating Laurentide Ice Sheet; often overlain by organic deposits in low-lying regions; massive to poorly stratified; moderately sorted; <2 m thick.

GLr — **Beach sediments:** cobble-gravel to sand ridges; formed during regression of glacial Lake McConnell; low-relief (≤2 m) ridges; poor to moderately sorted; weakly stratified and open framework.

GLn — **Littoral and nearshore sediments:** sand, silt, and minor clay; often infills regions between beach ridges; low relief; moderately sorted; <2 m thick.

GLv — **Veneer:** gravel, sand, and silt; a thin, sometimes discontinuous, drape of littoral sediments over bedrock such that bedrock topography and outcrops are discernible; <1 m thick.

GL — **Undifferentiated sediments:** sand, silt, and minor clay; may include minor regions of nearshore sediments; may be locally overlain by thin (<1 m) organic sediments; iceberg scour tracts are common; <4 m thick.

GLACIOFLUVIAL SEDIMENTS: gravel, sand, and minor silt deposited by glacial meltwater from, or in contact with, glacial ice in a subglacial, subaqueous, or subaerial setting; winnowed from inundation by glacial lakes; poorly to well stratified; variable thickness.

GFf — **Outwash-fan sediments:** fan-shaped morphology; moderately sorted; sediments fine toward distal edge; <2 m thick; **GFf2**, subaqueous fan deposited proximal to distal submerged glacier margin; often forms at the distal end of subglacial meltwater corridors where they terminate in a proglacial lake; variable thickness.

GFh — **Hummocky:** gravel to fine sand, with minor silt and isolated cobbles; massive to crudely stratified, moderate to poor sorting; commonly deposited in ice-contact environments, often associated with meltwater corridors; local relief of hummocks is <4 m.

GFr — **Esker:** gravel and sand; well sorted; massive to cross-stratified; linear to sinuous ridges; typically discontinuous short segments of larger subglacial fluvial corridors; up to 3 m high.

GF — **Undifferentiated sediments:** undifferentiated glaciofluvial sediments; variable thickness.

TILL DEPOSITS: diamictons deposited directly by the Laurentide Ice Sheet; sand, silt, and minor clay matrix, with striated and faceted clasts of varying lithologies derived from the Canadian Shield and Devonian carbonate bedrock; 10% to 20% clast content; generally <4 thick but locally thicker in the lee-side tails of streamlined glacial landforms and in larger moraine ridges; winnowed in areas of former proglacial lake inundation, producing a veneer (<1 m) of discontinuous, open-work, cobble-boulder lag with sorted gravel and sand.

Tm — **Moraine complex:** discontinuous moraine ridges associated with ice-thrusted till near the margin of a retreating ice sheet; moraine ridges comprise massive till sequences, with steeply dipping clasts; >20 m thick; locally restricted to Moraine Point, on the western shore of Great Slave Lake.

Tr — **Ridged till:** contiguous minor moraine ridges, subparallel and often transverse to other glacially streamlined landforms; associated with thrust ridges and crevasse-fill ridges; ≤3 m high.

Ts — **Streamlined till:** associated with large, parallel ice-flow landforms including flutings, crag-and-tails, drumlins, and mega-scale glacial lineations; variable thickness.

Tv — **Veneer:** discontinuous veneer such that underlying bedrock topography and outcrops are discernible; <2 m thick.

Tb — **Blanket:** continuous till cover with undulating relief; >2 m thick.

PRE-QUATERNARY

BEDROCK, PALEOZOIC

R — **Undifferentiated sedimentary bedrock:** platform Lower to Middle Devonian carbonate strata; exposed as isolated outcrops and near the western margin of Great Slave Lake; modern karst sinkholes are common, especially in the Middle Devonian Lonely Bay Formation.

Geological contact, defined

Thermokarst depression

Dune crest

Winnowed sediments, gravel and sand, and local cobble lag deposits; sorted; thin (<0.5 m)

Terrace scarp

Beach crest

Kettle

Iceberg scour central axis

Minor meltwater channel:
- *Direction unknown*
- *Direction known*

Moraine ridge:
- *Minor*
- *Major*

Esker ridge:
- *Direction unknown*
- *Direction known*

Buried drumlinoid ridge

Drumlinoid ridge

Crag-and-tail ridge

Sinkhole

Small outcrop

Station location:
- *Remote observation*
- *Ground observation*

Till sample location

Recommended citation
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CANADIAN GEOSCIENCE MAP 443

Geological Survey of Canada
Canadian Geoscience Maps

Authors: R.C. Paulen and I.R. Smith

Geology based on fieldwork (2018), air photographs (1970 and 1971; 1:60 000), and ArcticDEM (v.7) imagery (Porter et al., 2018)

Geology and geological compilation by R.C. Paulen, 2018

Geological data conforms to Surficial Data Model v. 2.4.0 (Deblonde et al., 2019)

Geomatics by L. Robertson

Cartography by E. Wieleba and N. Côté

Scientific editing by L. Ewert

Initiative of the Geological Survey of Canada, conducted under the auspices of the GEM-2 Southern Mackenzie Surficial Project as part of Natural Resources Canada's Geo-mapping for Energy and Minerals (GEM) program

Logistical support provided by the Polar Continental Shelf Program (PCSP) as part of its mandate to promote scientific research in the Canadian north, PCSP 058-18

Map projection Universal Transverse Mercator, zone 11
North American Datum 1983

SURFICIAL GEOLOGY
SULPHUR BAY
Western Great Slave Lake, Northwest Territories
NTS 85-G
1:125 000

2 0 2 4 6 8 10 km

Base map at the scale of 1:50 000 from Natural Resources Canada, with modifications
Elevations in metres above mean sea level

Mean magnetic declination 2022, 16°18'E, decreasing 8.8' annually. Readings vary from 16°52'E in the NW corner to 15°43'E in the SE corner of the map.

This map is not to be used for navigational purposes.

Title photograph: A thick exposure of till at Moraine Point, on the western shore of Great Slave Lake, Northwest Territories, (lat. 61°35'52.77"N long.115°37'51.04"W). Photograph by R.C. Paulen. NRCan photo 2020-861

The Geological Survey of Canada welcomes corrections or additional information from users (gscpublications-cgcpublications@nrcan-rncan.gc.ca).

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Canada

CANADIAN GEOSCIENCE MAP 443
SURFICIAL GEOLOGY
SULPHUR BAY
Western Great Slave Lake, Northwest Territories
NTS 85-G