Descriptive Notes

This map area is situated in southern Northwest Territories, bordering Alberta, and includes the northeastern extents of the Cretaceous bedrock Cameron Hills upland. The eastern flanks of this upland drain towards Hay River; while most of the upland drains via the Cameron River northwards into Tathlina Lake (~277 m above sea level[1] (a.s.l.)). The uppermost elevation of Cameron Hills within the map sheet is ~870 m a.s.l. and the upland surface is largely flat to gently rolling, dipping southwest at a 0.2° slope. The most prominent relief is attributable to glacial meltwater incision of the Cameron River and its tributary valleys (40–150+ m), moraines, and the conspicuous mega-scale glacial lineations (MSGL). Field investigations, aerial-photograph interpretation, and seismic-shothole drillers' logs (Smith and Lesk-Winfield, 2010; Smith, 2011) reveal that the upland surface is covered by extensive bog mantling a thick till blanket, contrary to Krabbendam et al. (2016) who suggested extensive till veneer and bedrock at surface. The map area is situated within the sporadic, discontinuous permafrost zone (Heginbottom et al., 1995), and numerous sites with shallow active layers (<1 m) were encountered over the course of fieldwork. Thermokarst terrain (melting of ice-rich permafrost) within areas of bog and fen is extensive.

Flutings preserved along the upper eastern margin of Cameron Hills record the earliest streaming of ice across the upland margin (220° azimuth). These were crosscut by a prominent MSGL field that covers much of the lower third of the map, and is part of a larger field (60 km long by 20 km wide; Paulen and Plouffe, 2009) extending southwest (246° azimuth) across eastern Cameron Hills. These two azimuths are similar to the earliest striae records on bedrock (230°) in areas north of Cameron Hills. Differences likely reflect initial topographic deflection of ice flow around Cameron Hills, and then continued topographic influence of flow as the Laurentide Ice Sheet subsumed Cameron Hills. Average MSGL fluting parameters reported by Spagnolo et al. (2014; based on Landsat imagery interpretations) are: 2.4 km long, 104 m wide, and 224 m spacing. ArcticDEM data (Porter et al., 2018) indicate that MSGL amplitudes are generally low (2–5 m), but range up to 10 m. Larger, elongate macroforms (1.5–3 km wide, 20–40 km long, 10–30 m high) underlying the finer MSGL flutings, and rectilinear lake margins accordant with ice-thrusted hill-hole pair morphology, suggest a complex process of ice-bed-bedrock interaction and landscape formation has occurred in the development of this MSGL field.

Ice retreat from Cameron Hills is recorded by southward-draining meltwater channels that crosscut many of the MSGL flutings. A subsequent north to south readvance, likely involving surging, is recorded by a series of streamlined landform flow sets along the northern edge of Cameron Hills, and ice-thrust and lobate moraines that override, but do not entirely conceal, MSGL flutings to the south. Subsequently, northward retreat of ice is recorded by a series of moraines. At that time, drainage was channeled southwestward across the upland toward the Peitot River drainage system (southwest of the map area), before a clockwise rotation of the retreating ice margin led to the incision of the northward-draining Cameron River meltwater canyon. Bedrock-striae evidence of late westward to northwestward ice flow north of Cameron Hills (280° and 305°; Paulen et al., 2019) is not reflected by the azimuth of deglacial-phase glacial lineations and moraine alignments on Cameron Hills. This suggests significant topographic control on both the north-south aligned features on Cameron Hills, and deglacial ice-flow directions in areas north of Cameron Hills.

During final retreat of ice off Cameron Hills, glacial-meltwater drainage northward down the progressively deepening Cameron River meltwater canyon was likely channeled subglacially northwestwards towards the proto–Mackenzie River basin. As ice continued to thin and retreat northeastward across the boreal plains, a large ice-dammed lake formed against the lower slopes of Cameron Hills. Isolated patches of glaciolacustrine sediment and faint beach ridges from ~325 down to 295 m a.s.l mark disparate proglacial lake levels until, at ~295 m a.s.l, an expansive (>200 km²) delta was formed within an ice-dammed glacial lake occupying the Tathlina, and possibly combined Tathlina and Kakisa, lake basins. The modern Cameron River incises parts of this raised delta, and the majority of its former extent lies beneath a blanket of bog and fen cover.

Twelve samples of till were collected for heavy-mineral identification (e.g., kimberlite indicators and magmatic and massive sulphides) and matrix geochemical analyses (Paulen et al., 2019). Samples were collected from shovel-dug pits at depths generally 1 m or more, and from natural stream-cut exposures.

There are large potential granular-aggregate deposits found within glaciofluvial sediments on Cameron Hills, including those associated with kames, eskers, terraces, and outwash deposits. The prominent east-west tributary channel of the Cameron River, just before it drains northwards off Cameron Hills, includes a >30 m exposure of a high-energy glaciofluvial outwash deposit of sandy cobble-gravel, including 2 to 4 m thick lenses of closed-work boulders (up to 1.5 m diameter boulders; includes many Canadian Shield lithologies).

[1]Reported elevations above sea level are based, where possible, on national topographic system (NTS) datums. Elevations (m a.s.l.) interpreted from ArcticDEM data are adjusted using the nearest NTS datum. ArcticDEM data are considered to provide reliable measures of local and landform relief.

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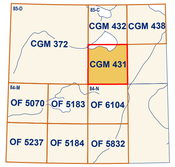
Abstract

The northeastern Cameron Hills comprise a Cretaceous bedrock upland, rising >550 m above the regional boreal plains. It was inundated by the Laurentide Ice Sheet and includes much of a prominent 60 by 20 km southwest-oriented mega-scale glacial lineation field, formed in thick till. Subsequent ice flow on northeast Cameron Hills occurred north to south, and a series of lobate and ice-thrust moraines suggest glacial surging. Rotational bedrock slumps cover the eastern and northern flanks of Cameron Hills, and extensive alluvial fan deposits draining from these slopes blanket the surrounding topography. The Cameron River formed as a glacial spillway, draining southwest across the upland before turning north and draining into Tathlina Lake. An expansive raised delta and glaciolacustrine sediment cover extending up to ~295 m above sea level, south of Tathlina Lake, records impoundment of an ice-marginal lake between the northeastward-retreating Laurentide Ice Sheet and Cameron Hills.

Résumé

Le nord-est des collines Cameron est constitué de hautes terres formées d'un substratum rocheux d'âge crétacé, qui s'élèvent à plus de 550 m au-dessus des plaines boréales de la région. Ce secteur a été envahi par l'inlandsis laurentidien et renferme la majeure partie d'un remarquable champ de linéations glaciaires de direction sud-ouest à grande échelle formées dans un till épais, qui s'étend à une superficie de 60 sur 20 km. Un écoulement glaciaire subséquent dans la partie nord-est des collines Cameron dirigé du nord au sud ainsi qu'une série de moraines lobées et de moraines de chevauchement suggèrent une crue glaciaire. Les traces de glissements rotationnels dans le substratum rocheux parsèment les flancs est et nord des collines Cameron, et d'importants dépôts de cône alluvial tirant leur source de ces versants recouvrent la topographie environnante. La rivière Cameron est apparue sous forme de déversoir glaciaire, où les eaux s'écoulaient vers le sud-ouest à travers les hautes terres avant de s'inverser vers le nord pour aboutir dans le lac Tathlina. Au sud du lac Tathlina, un vaste delta soulevé et une couverture de sédiments glaciolacustres s'étendant jusqu'à environ 295 m au-dessus du niveau de la mer témoignent de la formation d'un lac de marge glaciaire retenu entre l'inlandsis laurentidien, qui se retirait vers le nord-est, et les collines Cameron.



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

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CANADIAN GEOSCIENCE MAP 431
SURFICIAL GEOLOGY
NORTHEASTERN CAMERON HILLS
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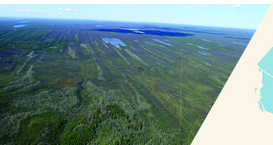
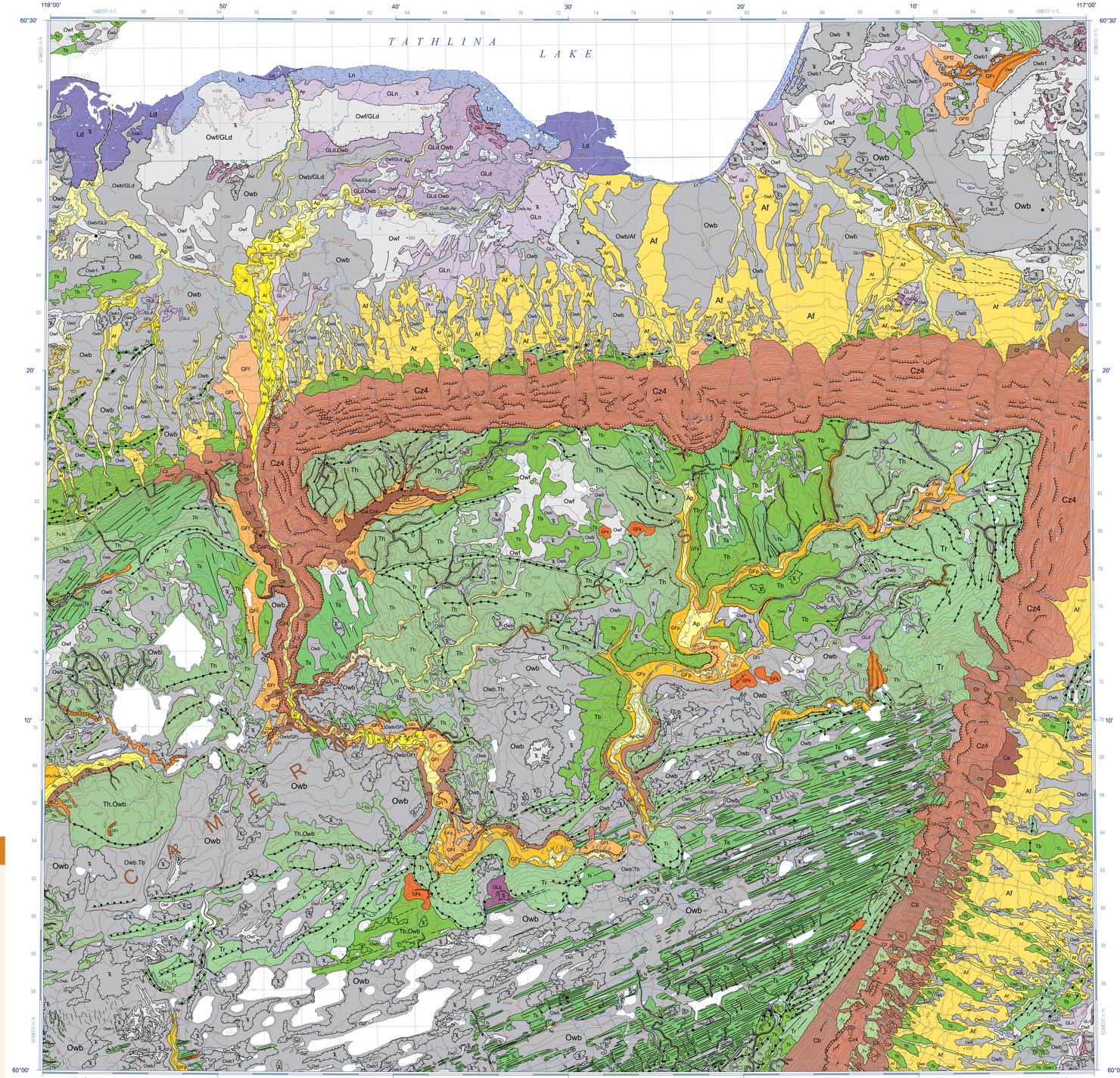
1:100 000





QUATERNARY

POST LAST GLACIATION

NONGLACIAL ENVIRONMENT

ORGANIC DEPOSITS: peat and muck; formed by the accumulation of plant materials in various stages of decomposition; occurs as low relief, wet terrain over poorly drained substrates; average 1 to 3 m thick, and locally up to 9 m thick.

Fen: semi-open peatlands derived from sedges and partially decayed shrubs in an eutrophic environment; mineral-rich water table persists seasonally at surface; commonly with ribbed patterns transverse to drainage; generally covered with low shrubs and occasional trees; locally affected by permafrost conditions; may contain areas with extensive thermokarst (separately labelled).

Bog: *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 (separately labelled); **Owb1**, raised peat-plateau morphology related to ground ice, and underlying fen or glaciofluvial surface; may contain areas with extensive thermokarst (separately labelled).

COLLUVIAL AND MASS-WASTING DEPOSITS: diamicton formed by direct, gravity-induced movement; composition dependent on source material; poorly-sorted; massive to stratified; variable thickness.

Cf — **Fan:** focused accumulation of colluvial deposits at base of slope forming a fan-shaped morphology; >2 m thick.

Ca — **Apron:** colluvial deposit accumulations toward the base of a slope; deposited by nonchannelized flow; > 2 m thick.

Cz — **Landslide and slump debris:** active and inactive landslides; hummocky relief; 1 to 10 m thick but may exceed 10 m near the toe of large landslides; **Cz4** rotational landslide; **Cz5** translational landslide.

Cv — **Colluvial and mass-wasting deposits, veneer:** undifferentiated colluvial deposits; <2 m thick.

Cb — **Colluvial and mass-wasting deposits, blanket:** undifferentiated colluvial deposits; >2 m thick.

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

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

Af — **Fan:** fan-shaped morphology; may show migrating stream incisions across surface; poorly sorted; >1 m thick.

At — **Terrace:** inactive terraces above modern floodplain; may exhibit sharp successive scarps defining different terrace levels; sorted; >2 m thick.

Ab — **Alluvial sediments, blanket:** undifferentiated alluvial deposits; >2 m thick.

A — **Alluvial sediments, undifferentiated:** undifferentiated alluvial deposits; variable thickness.

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

Lr — **Ridged beach sediments:** pebble gravels, sand and silt; ridges often prominent on eastern lake margins as ice-push ramparts; weakly stratified; ≤2 m thick.

Ld — **Delta:** accumulation of sorted sediments at the point where a stream enters a lake; stratified; flat to gently inclined; progrades into the lake; >2 m thick.

Ln — **Littoral and nearshore sediments:** well sorted gravel, sand and silt; deposited in littoral settings; <2 m thick.

NONGLACIAL AND PROGLACIAL ENVIRONMENTS

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

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

Ev — **Eolian sediments, veneer:** discontinuous cover; <2 m thick.

E — **Eolian sediments, undifferentiated:** isolated patches, or inter-dune areas; variable thicknesses.

POSTGLACIAL OR LATE WISCONSINAN

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; average <2 m thick.

GLr — **Ridged beach sediments:** cobble-gravel to sand ridges; formed along the margins of proglacial lakes; low relief (≤2 m) ridges; poorly to moderately sorted; weakly stratified and open framework.

GLd — **Delta:** raised delta formed in a proglacial lake, fed by glaciofluvial and/or regional deglacial drainage; may exhibit descending and incised, flat to gently inclined terraces accordant with falling lake levels; 1 to >10 m thick.

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

GLb — **Glaciolacustrine sediments, blanket:** undifferentiated glaciolacustrine sediments; >2 m thick.

GLACIOFLUVIAL SEDIMENTS: gravel, sand, and minor silt deposited by glacial meltwater from, or in contact with, glacial ice in a subglacial or subaerial setting; channels may incise till and/or bedrock; locally winnowed where inundated by glacial lakes; poorly to well stratified; variable thickness.

GFp — **Outwash plain:** low-relief deposit often found adjacent to glacial meltwater channels; moderately sorted; massive to crudely stratified; >2 m thick.

GFt — **Terrace:** terraces formed along former glaciofluvial floodplain; flat-topped; moderately to well sorted; >2 m thick.

GFf — **Outwash fan:** fan-shaped morphology; moderately sorted; sediments fine toward distal edge; >2 m thick; **GFf2**, subaqueous grounding-line fan deposited at, or immediately distal to, submerged glacier margin; often forms at the distal end of esker channels where they terminated in a proglacial lake; variable thickness.

GFk — **Kame:** sand and gravel; well to moderately sorted; flat-topped terraces and isolated hills deposited from either meltwater impounded between the ice sheet and topography, or into an embayment within the ice sheet itself; ≤8 m thick.

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 5 m thick.

GF — **Glaciofluvial sediments, undifferentiated:** undifferentiated glaciofluvial sediments; variable thickness.

TILL DEPOSITS: diamictons deposited directly by the Laurentide Ice Sheet; sandy-silt to clayey-silt matrix; 5 to 15% clast content, derived from Canadian Shield and local Cretaceous and Devonian lithologies with rare Cordilleran pebbles; <20 m thick; winnowed in areas of former glacial lake inundation producing a thin (<0.5 m), discontinuous, open-work, cobble-boulder lag.

Th — **Hummocky till:** hummocky till surface, sometimes ridged; >2 m thick.

Tr — **Ridged till:** contiguous moraine ridges; subparallel; includes thrust moraines, crevasse-fill ridges and De Geer moraines; ≤5 m thick.

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

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

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

PRE-QUATERNARY

BEDROCK, CRETACEOUS

R — **Bedrock, undifferentiated sedimentary:** fine-grained (shale, siltstone, and mudstone) Cretaceous sedimentary strata; exposed at base of rotational slump blocks along flanks of Cameron Hills, and along the Cameron River and other drainages off Cameron Hills; includes the Fort St. John Group – Shaftesbury, Scatter, and Loon River formations; Devonian carbonates underlie Quaternary sediments and the Cretaceous strata, but do not outcrop within the map area.

Complex units: two map-unit designators separated by a dot (.) are used where the surficial cover forms a complex area and the units are too small to be mapped individually (e.g., GLd.Owb denotes an area of glaciolacustrine deltaic sediments with organic bog deposits). The map-unit polygon is coloured according to the dominant unit and labeled in descending order of cover.

Stratigraphic relationship: two map-unit designators separated by a slash (/) are used where a stratigraphic relationship is observed or confidently inferred (e.g. Owf/GLd indicates organic fen deposits overlying glaciolacustrine deltaic sediments). The map-unit polygon is coloured according to the overlying unit.

Thermokarst depression:
Area of widespread, often small individual thermokarst pond development
Small

Geological boundary, defined

Fluvial terrace and landslide scarps

Beach crest:
Lacustrine
Glaciolacustrine

Iceberg scour

Meltwater channel:
Minor, central axis (direction unknown)
Minor, central axis (direction known)
Minor, central axis (lateral uphill right)
Minor, central axis (lateral uphill left)
Major, scarp

Moraine:
Minor
Minor, De Geer moraine
Major

Ice-thrust ridge

Esker ridge:
Direction unknown
Direction known or inferred

Drumlin ridge, direction known

Fluted drift:
Central long axis (buried; direction unknown)
Central long axis (buried; direction known)
Central long axis (well defined; direction unknown)
Central long axis (well defined; direction known)

Station location (ground observation)

Till sample location

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CANADIAN GEOSCIENCE MAP 431

Geological Survey of Canada
Canadian Geoscience Maps

Authors: I.R. Smith, R.C. Paulen, and G.W. Hagedorn

Geology by I.R. Smith, R.C. Paulen, and G.W. Hagedorn, based on fieldwork (2017 and 2018), air photographs (1971, 1:60 000), and ArcticDEM (v.7) imagery.

Geological compilation by I.R. Smith, 2018 and 2019

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

Geomatics by L. Robertson

Cartography by M.J. Baldock

Scientific editing by A. Weatherston

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

Logistical support provided by the Polar Continental Shelf Program (PCSP) as part of its mandate to promote scientific research in the Canadian north, PCSP 057-17 and 058-18

SURFICIAL GEOLOGY
NORTHEASTERN CAMERON HILLS
Northwest Territories
NTS 85-C/3, 4, 5, and 6
1:100 000

2 0 2 4 6 8 km

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

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 2021, 17°11'E decreasing 9.0' annually
Readings vary from 17°23'E in the NW corner to 16°56'E in the SE corner of the map.

This map is not to be used for navigational purposes.

Title photograph: Mega-scale glacial lineation (MSGL) field, Cameron Hills, Northwest Territories. Photograph by I.R. Smith. NRCan photo 2020-098

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Data may include additional observations not portrayed on this map. See map info document accompanying the downloaded data for more information about this publication.

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

CANADIAN GEOSCIENCE MAP 431
SURFICIAL GEOLOGY
NORTHEASTERN CAMERON HILLS
Northwest Territories
NTS 85-C/3, 4, 5, and 6