MARGINAL NOTES

LANDSCAPE EVOLUTION

Sedimentation into the Old Crow Basin during the Neogene (~23-2.6 Mya) was dominated by shallow rivers and lakes that filled the basin with silt, sand and gravel. Lacustrine and fluvial sediments have been exposed by late Pleistocene fluvial incision along the Porcupine and Crow rivers and record basin sedimentation that was likely controlled by continued uplift in the surrounding mountains and relative depression of the Old Crow basin. Tephra from some of the oldest lake sediments is thought to been deposited more than 1.2 Mya, however, fossil wood, cones and pollen from these exposures all suggest the sediments could be considerably older, and potentially extend into the early Neogene (*e.g.,* Schweger, 1989). Late Neogene fluvial sediments grade to considerably higher base levels than exist today and are thought to have been part of the paleo-Mackenzie River drainage prior to glacial meltwater diversions in the late Pleistocene (Duk-Rodkin and Hughes, 1995).

The modern course of the Porcupine River is thought to have been established during the late Pleistocene when glacial lakes overflowed into the Old Crow Basin and cut a new western outlet to the Yukon River (Hughes, 1972). Prior to this diversion, regional streams drained eastward into the paleo-Mackenzie River. When the most extensive advance of the Laurentide Ice Sheet occurred in the late Pleistocene, it blocked drainage through the Richardson Mountains and impounded a large glacial lake in the Old Crow, Bell, Driftwood and Bluefish basins (Zazula *et al.*, 2004). Strandlines to at least 360 m a.s.l. in the Old Crow Basin mark the high stand of glacial Lake Old Crow ~15,000 to 20,000 years ago, before incision of the Ramparts of the Porcupine River drained the lake and established the modern course of the Porcupine River and its tributaries (Kennedy *et al.*, 2010; Thornson and Dixon, 1983). Deposition in the study area during the Pleistocene was dominated by colluvial and fluvial processes. Changes to the landscape during this time include the deposition of fluvial terraces along the Porcupine River, and blankets, aprons and fans of colluvium. Slow periglacial wasting mechanisms (solifluction, slopewash) have likely dominated colluvial processes throughout the Pleistocene and into the modern era.

Holocene landscape evolution in the study area was conditioned by the amelioration of periglacial conditions and a gradual infilling of the Porcupine River valley margins. Valley-side colluvial deposits and abandonment of the high terraces along the Porcupine River resulted in the modern broad, poorly drained valley floor. Landscape evolution of the Old Crow map area continues in historic times as the result of community development on the floodplain terrace of the Porcupine River and the hillslope above.

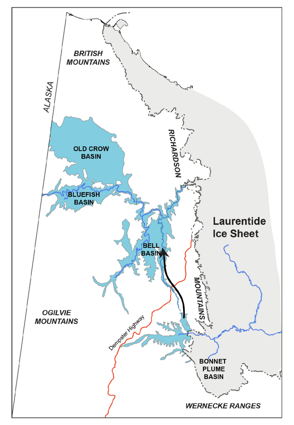


Figure 1. The maximum western advance of the Laurentide Ice Sheet is thought to have impounded easterly-flowing rivers in northern Yukon and formed a large proglacial lake in the Bonnet Plume, Bell, Bluefish, and Old Crow Basins.

STRATIGRAPHY

A water well drilled beneath Old Crow encounters bedrock nearly 40 m below where it occurs on the Crow River in the map area, and records evidence of a fault ~80 m below river level. Both observations support the interpretation of a rapidly descending bedrock surface caused by either a fault-dropped block, or a change in rock competence caused by faulting that allowed for preferential erosion in the Porcupine River valley. Lacustrine sediments are interpreted to comprise at least 25 m of sediments buried beneath the modern channel of the Porcupine River. These lake deposits are also preserved above the modern river along the escarpment above Old Crow where they occur to ~280 m a.s.l. Lacustrine sediments are overlain by up to 20 m of fluvial sand and gravel deposits. These units were likely all in place before the late Pleistocene diversion of the Porcupine River that incised its modern channel ~50 m lower than the former river channel. Since the new channel was established, deposition has been in the form of colluvial blankets (both on the shallow upland pediment and along the steep flank of the escarpment), and fluvial plains and terraces. The community of Old Crow is built upon a fluvial terrace that has largely been abandoned by the modern course of the Porcupine River.

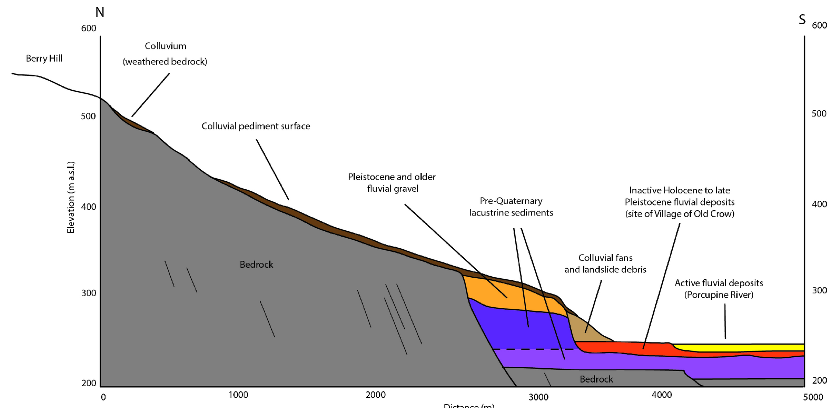


Figure 2. Cross-valley profile of sediments in the Porcupine River valley at Old Crow.

Figure 3. Pleistocene or older fluvial sediments overlain by colluvial diamict at the top of the escarpment in Old Crow.

Figure 4. Laminated lacustrine sediments occurring up to 30 m above river level.

GEOLOGIC HAZARDS

Landslides

Landslides in the Old Crow map area have been mapped through observations of mass movement on the ground (*i.e.*, slumped material, landslide debris, tension cracks, split trees and stretched roots), from historic and modern imagery of the map area (*i.e.*, aerial photographs and satellite images), and from digital elevation models of the earth's surface. The bulk of detailed mapping was made possible by the acquisition of a one metre or better resolution elevation surface created with a LiDAR dataset collected in 2014. More than 100 landslide head scarp features were mapped across the ~6 km-long escarpment above Old Crow. These features represent both ancient and recent mass wasting events.

Landslides initiated above ~300 m a.s.l. have crescent-shaped head scarps and small debris cones close to the base of the slope. These landslides are interpreted as debris falls and are relatively small and active features that release material as permafrost melts in the exposed face of the slope. Debris-fall landslides also occur where slopes are being undercut by river erosion, by mass wasting in lower stratigraphic units, or by other natural and anthropogenic modifications that remove material from the base of the slope. Debris-fall landslides are interpreted to occur in permafrost-affected fluvial and colluvial materials, and as such, are sensitive to climatic factors such as heat and precipitation which diminish permafrost and may contribute to instability on these slopes.

Landslides initiated below ~280 m a.s.l. are characterized by shallow translational slides, also known as active layer detachment or thaw-flow slides. These slides are characteristic of a type of fast periglacial mass wasting that occurs where the thawed or thawing part of the active layer detaches from the underlying frozen material and moves downslope through sliding and sometimes flowing of the thawed debris. Events that cause rapid thickening of the active layer combined with high pore water pressure, such as forest fires and hot and/or wet weather, commonly trigger active-layer detachments. These landslides are likely to have head scarps characterized by linear cracks which may propagate into undisturbed materials upslope of the head scarp (*i.e.*, tension cracks). Active layer detachment slides occur when sufficient water collects at the base of the active layer to allow overlying saturated sediments to slide on a thin layer of water, ice, and/or mud (Lewkowicz, 2007). As a result, these thaw detachments are most common in fine-grained soils on slopes underlain by ice-rich permafrost and in association with areas of surface water convergence such as water tracks (Kokelj and Joergenson, 2013).

Figure 7 illustrates stratigraphic controls on landslide generation in the study area. Neogene and older lacustrine sediments (zcLb>Q) are susceptible to thaw-detachment slides because they are fine grained (primarily silt), ice rich, and are covered in blankets of silty colluvium that can become mobilized when saturated. Ice lenses at the base of the active layer are common in this unit, and when this layer thaws rapidly it can release water into already wet soils and trigger sliding in the thawed part of the slope. Alternatively, overlying sand (sFb), gravel (sgFb), and diamict (dzCpbv) materials are more likely to be affected by debris fall mass wasting because they maintain steeper slopes, are well drained, and are less ice rich than lacustrine units. Surface water from Berry Hill drains easily through the thawed components of high-level sand and gravel deposits before saturating the poorly drained active layer soils of the lacustrine and colluvial deposits on the lower slopes of the escarpment. Additional water added to these materials through heavy rain, or thawing of ice lenses at the base of the active layer, can cause rapid increases in pore water pressure that triggers detachment slides.

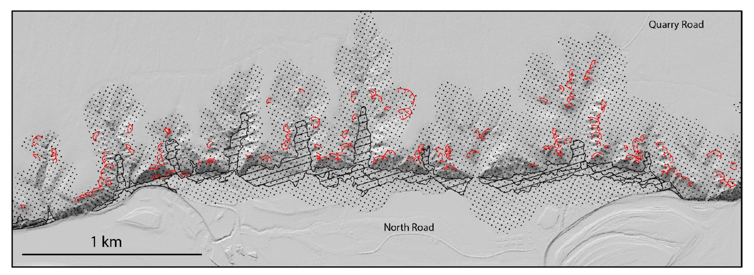


Figure 5. Distribution of landslide head scarps (red lines), terrain blanketed with landslide deposits (cross-hatched pattern), and terrain with the potential for landslide activity (stippled pattern) in Old Crow.

Figure 6. A large landslide generated after heavy rainfall in August 2011 had two distinct source areas and a run-out zone that crossed a nearby road.

Figure 7. Tension cracks that spread the ground's surface are abundant on the bluff above Old Crow.

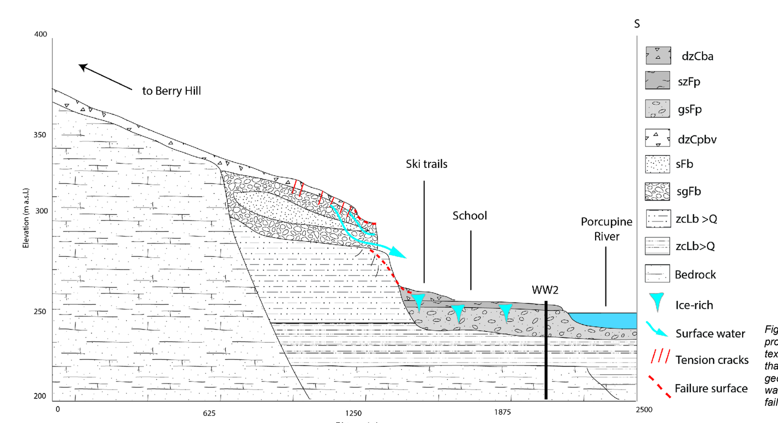


Figure 8. Idealized cross-valley profile of the map area with unit textures and landform descriptions that correspond with the surficial geology map legend. Surface water drainage and hypothesized failure surfaces are indicated.

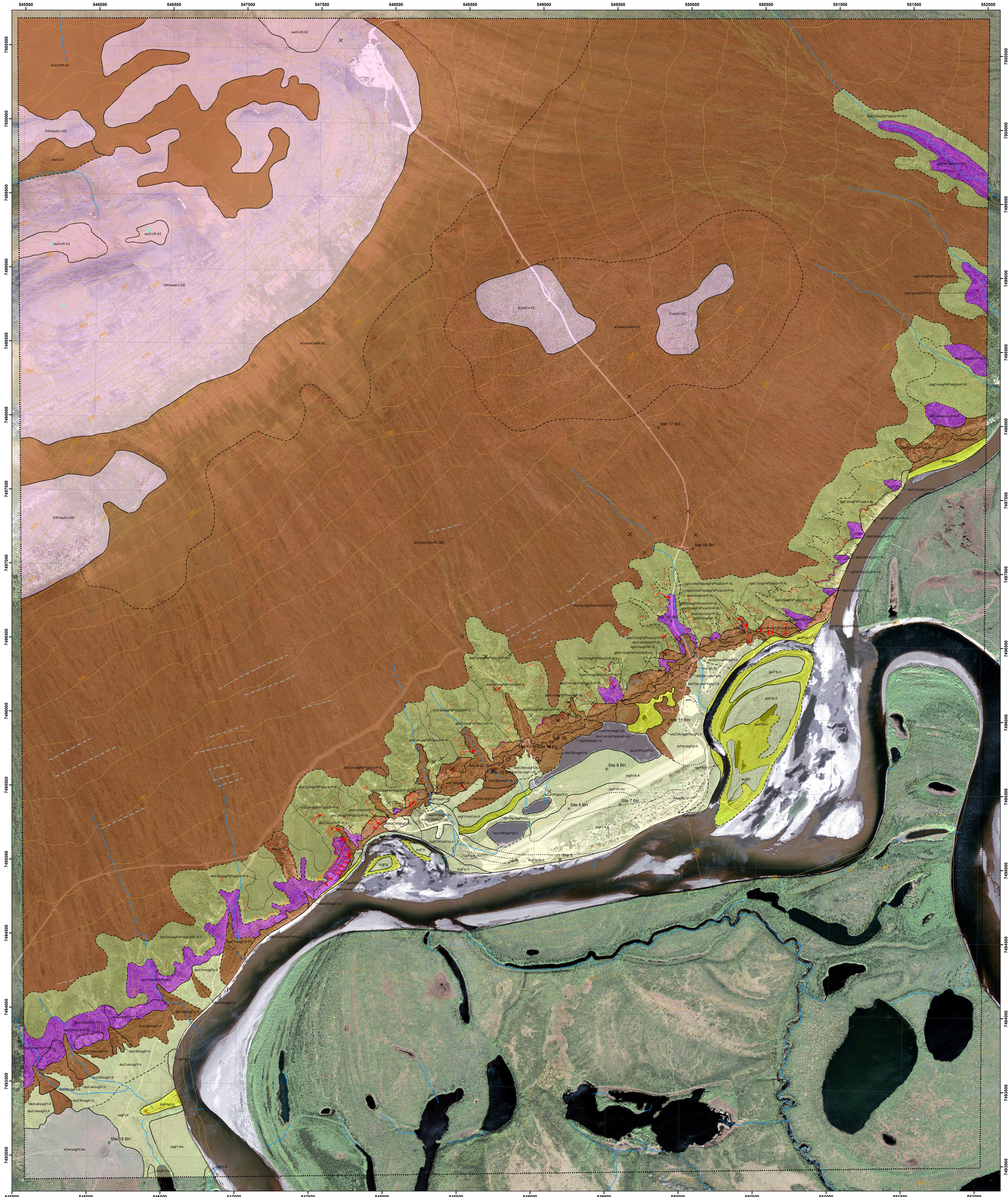
Slow periglacial wasting

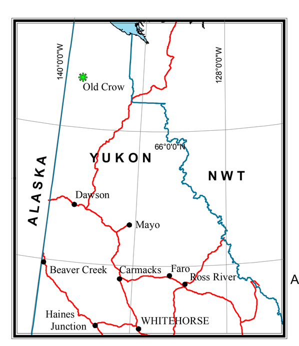
Periglacial wasting is a general term that describes cold-climate colluvial processes that are mediated by freeze-thaw and permafrost conditions. Periglacial wasting includes both slow processes such as solifluction, slopewash, solution, nivation, and rapid processes such as active layer detachments. Slopewash (also known as sheetwash), is difficult to quantify, but is a significant modifier of the landscape in the map area, particularly on the pediment slope below Berry Hill. Slopewash is characterized by unconcentrated surface wash where particles are carried downslope in an overland flow and deposited as fine, unconsolidated sediment, typically at the foot of slopes as a result of the continual percolation of water downslope. While unlikely to cause catastrophic events, slow periglacial wasting can be a significant hazard to infrastructure built upon, or at the base of, landforms that are experiencing gradual downslope movement. Examples of slow periglacial processes in the map area include the 'trees with knees' (Fig. 8), abundant tension cracks, hillslope terraces, and slumps that are all evidence of the slow downward movement of the escarpment slope. It is unclear how slow periglacial processes contribute to rapid mass wasting processes, but evidence of slow slope movement may be a sign of increasing slope instability leading to larger mass wasting events.

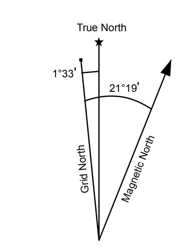
Permafrost

Permafrost may be found within any of the materials described on the accompanying map. Ice-rich permafrost is common and may be present on all aspects and in moderately to well drained materials as well as poorly drained materials. Near surface permafrost within one metre of the surface is encountered on most slopes, as well as on more level valley-bottom sites where there is an insulating cover of organic material and or finer textured soils. High ice contents are common especially where there is, or has been, subsurface or water flow associated with larger rivers as well as surface or smaller drainages and fans. Permafrost influences slope stability by strongly affecting drainage (which is restricted by the permafrost table), soil moisture (which may increase in response to rapid thaw of ground ice), and strength (through bonding of frozen soil particles). Disturbance or clearing of the organic cover, and/or changes in surface or subsurface drainage, can cause changes to the soil thermal regime and result in thermokarst, thaw subsidence, and terrain destabilization. Thermokarst depressions result from the thaw of ground ice and subsequent settlement of the ground surface. Fine-grained, ice-rich sediments are most susceptible to thermokarst collapse following some kind of surface disturbance which exposes ground ice. Thermokarst depressions may grow in size for decades until the supply of ground ice is exhausted.

Figure 9. Example of a tree bent by slow periglacial mass wasting on a slope above the floodplain in Old Crow.







Use diagram only to obtain numerical values
APPROXIMATE MEAN DECLINATION FEBRUARY 2016
FOR CENTRE OF MAP

1:50 000 scale topographic base data produced by CENTRE FOR TOPOGRAPHIC INFORMATION, NATURAL RESOURCES CANADA

Copyright Her Majesty the Queen in Right of Canada

ONE THOUSAND METRE GRID
Universal Transverse Mercator Projection
North American Datum 1983
Zone 7

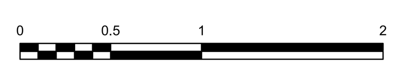
CONTOUR INTERVAL 25 FEET
Elevations in feet above Mean Sea Level

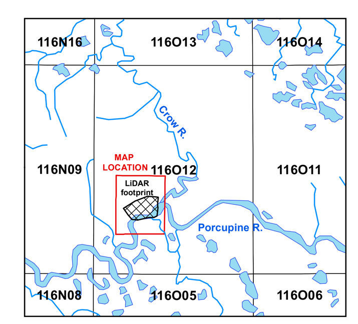
SURFICIAL GEOLOGY

OLD CROW, YUKON TERRITORY

PARTS OF NTS 116O/12

SCALE 1:10 000





TERRAIN CLASSIFICATION SYSTEM

This surficial geology map was classified using the Terrain Classification System for British Columbia (Howes and Kenk, 1997), with minor modification to meet standards set by the Yukon Geological Survey. For example, we have added some permafrost process subclasses to accomodate the wider variety of permafrost features found in Yukon. We have also added an age classification to distinguish materials deposited during different Pleistocene glaciations.

A sample map unit label is shown below to illustrate the terrain classification system. Surficial materials form the core of the polygon map unit labels and are symbolized with a single upper case letter. Lower case textures are written to the left of the surficial material, and lower case surface expressions are written to the right. An upper case activity qualifier (A = active; I = inactive) may be shown immediately following the surficial material designator. The glacial qualifier "G" may alternatively be written immediately following the surficial material to indicate glacially modified materials. Age is indicated by a capital letter that follows the surface expression but precedes the process modifiers. Geomorphological processes (capital letters) and subclasses (lower case letters) always follow a dash symbol ("-").

sgFGptM-Xs

- GEOMORPHOLOGICAL PROCESS(ES) (-X = permafrost) SUBCLASS(ES) (s = sheetwash)
- AGE (M = McConnell)
- SURFACE EXPRESSION (pt = plain, terrace)
- QUALIFIER (G = glacial; A = active; or I = inactive)
- SURFICIAL MATERIAL (F = fluvial)
- TEXTURE (sg = sand, gravel)

COMPOSITE SYMBOL DELIMITERS:

Due to scale limitations, up to 4 terrain units may be included in a single map unit label (*e.g.*, sgFGptM.dsmMbM/xsCv\zcLGpM-XsV). Each component is separated by a delimiter that indicates relative proportions between the components (".", "/", "//") or a stratigraphic relationship "\").

"." - terrain units on either side of the symbol are of approximately equal proportion
"/" - terrain unit(s) before the symbol is more extensive than the one(s) following
"//" - terrain unit(s) before the symbol is considerably more extensive than the one(s) following
"\" - terrain unit(s) before the "\" symbol stratigraphically overlies the one(s) following

1st terrain unit (>50% of map unit) / 2nd terrain unit (30-49% of map unit) // 3rd terrain unit (10-29% of map unit) \ Underlying terrain unit

TEXTURE

Texture refers to the size, shape and sorting of particles in clastic sediments, and the proportion and degree of decomposition of plant fibre in organic sediments. Texture is indicated by up to three lower case letters, placed immediately before the surficial material designator, listed in order of decreasing abundance.

Specific clastic textures

a - blocks: angular particles >256 mm in size
b - boulders: rounded particles >256 mm in size
k - cobbles: rounded particles >64-256 mm in size
p - pebbles: rounded particles >2-64 mm in size
s - sand: particles >0.0625-2 mm in size
z - silt: particles 2 μm-0.0625 mm in size
c - clay: particles ≤2 μm in size

Common clastic textural groupings

d - mixed fragments: a mixture of rounded and angular particles >2 mm in size
x - angular fragments: a mixture of angular fragments >2 mm in size (*i.e.*, a mixture of blocks and rubble)
g - gravel: a mixture of two or more size ranges of rounded particles >2 mm in size (*e.g.*, a mixture of boulders, cobbles and pebbles); may include interstitial sand
r - rubble: angular particles between 2 and 256 mm; may include interstitial sand
m - mud: a mixture of silt and clay; may also contain a minor fraction of fine sand
y - shells: a sediment consisting dominantly of shells and/or shell fragments

Organic terms

e - fibric: the least decomposed of all organic materials; it contains amounts of well-preserved fibre (40% or more) that can be identified as to botanical origin upon rubbing
u - mesic: organic material at a stage of decomposition intermediate between fibric and humic
h - humic: organic material at an advanced stage of decomposition; it has the lowest amount of fibre, the highest bulk density, and the lowest saturated water-holding capacity of the organic materials; fibres that remain after rubbing constitute less than 10% of the volume of the material

SURFICIAL MATERIAL AGE

TIME PERIOD	APPROXIMATE AGE
<M: Postglacial	<15 000 years ago
P - Pleistocene undifferentiated	15 000 to ~2.6 million years ago
>P - pre-Pleistocene	>2.6 million years ago

SURFICIAL MATERIALS

Surficial materials are non-lithified, unconsolidated sediments. They are produced by weathering, sediment deposition, biological accumulation, and human and volcanic activity. In general, surficial materials are of relatively young geological age and constitute the parent material of most (pedological) soils. Note that a single polygon will be coloured only by the dominant surficial material, but other materials may exist in that unit.

HOLOCENE

A — **Anthropogenic (A):** Surficial materials modified by human activities such that their original physical properties have been significantly altered. Applied to areas within the map containing significant quantities of quarried rock on the surface (*i.e.*, sewage lagoon, building pads).

O — **Organic (O):** Material derived from decomposition of organic matter and consists of peat with fibric to mesic decomposition. In this cool part of Yukon, organic materials accumulate on top of many surficial deposits including colluvial slopes, eolian deposits, and fluvial terraces and floodplains.
Organic blankets: Accumulations of vegetative matter thicker than 1 m are sometimes found on floodplains in old meander scars and thermokarst hollows, in shaded pockets on cool north-facing slopes, and on some poorly drained landforms of various material types. Near-surface permafrost is usually present.
Organic veneers: Veneers of organic material (20 to 100 cm thick) are widespread and are usually associated with near-surface permafrost. Organic veneers are present on almost all surfaces and have not been mapped.

L^{M} — **Lacustrine (L<M):** Modern sediments that have settled from suspension in bodies of standing water are limited to thin deposits in small bodies of standing water on the floodplain of the Porcupine River. Sediments consist of stratified fine sand, silt and clay deposited on the lake bed from suspension.

E — **Eolian (E):** Sediment transported and deposited by wind. The dominant eolian sediment in the map area is loess, which is predominantly silty in texture with a smaller fraction of fine sand. Eolian silt deposits are found on both upland and lowland surfaces in the study area, but occur most commonly along the edge of the bluff above town (cliff-top loess deposits). In cryoturbated and colluviated areas, which are extensive in the map area, loess is reworked into the soil profile and mixed with underlying sediments. Loess is not extensive in the map area, and is indicated by the "z" textural symbol within other geological material types.

HOLOCENE AND PLEISTOCENE

C — **Colluvium (C):** Material transported and deposited by down-slope, gravity-driven processes such as creep, solifluction, landslides and snow avalanches. Colluvium is the dominant surficial material above elevations of ~260 m a.s.l. in the map area. It commonly has a stratified structure with a highly variable texture and composition controlled by the parent material, transport mechanism, and travel distance. Colluvium on uplands and shallow pediment slopes is generally derived from weathered bedrock with minor contributions of loess, resulting in a silt-rich diamicton containing angular, local bedrock clasts. Colluviation on gentle upland slopes is dominated by slow colluvial processes such as sheetwash, solifluction and creep, and is characterized by greater accumulations of near-surface permafrost. On steeper slopes on the valley side, colluvium is generally coarser grained, as it has incorporated pre-Pleistocene fluvial materials and has been deposited by rapid mass wasting processes such as debris falls, slumps, and thaw-detachment slides. Colluvial aprons found on the lower slopes of the escarpment and the uphill side of the floodplain terrace commonly contain ice-rich permafrost and are primarily composed of resedimented slope materials.

F, FA — **Holocene Fluvial (F<M):** Sediments transported and deposited by modern streams and rivers, found in floodplains, fans and terraces. Fluvial deposits typically consist of well-sorted stratified sand and gravel comprising subangular to rounded clasts. Fluvial fans, fan-shaped landforms or complexes of fluvial and colluvial fan-shape landforms usually consist of silt, sand and gravel derived from colluvial material. Flat-lying fluvial deposits such as floodplain and terrace deposits can be well drained to poorly drained depending on the amount of coarse or fine sediments that make up the landform. Fine-grained fluvial deposits are commonly ice rich and contain massive ice. Floodplain and terrace deposits may be subject to flooding accompanied by sudden stream migration and inundation.
Active fluvial (FA<M): Sandy and gravelly materials subject to regular flooding.

PLEISTOCENE AND OLDER

F^{P} — **Fluvial (FP):** Sandy pebble and cobble gravel deposited by streams having a fluvial source graded to a former base level of the Porcupine River (possibly at ~280 m a.s.l.). Pleistocene and older fluvial deposits in the map area range from ~10-20 m thick, and are characterized by well-rounded, pebble-cobble gravel with laterally and vertically discontinuous beds of massive, planar and ripple cross-bedded sand. Gravel units range from cobble to pebble-dominated and can have both open-work and matrix-supported facies. Discontinuous sand units are usually 2-3 m thick and poorly exposed.

$L^{>P}$ — **Lacustrine (LP):** Stratified fine silt, clay and sand deposited on the bed of a lake that existed prior to Pleistocene changes in regional drainage. Neogene and older lacustrine sediments are found in the lowermost half of the stratigraphy exposed on the steep bluff above the floodplain of the Porcupine River. The top of the lacustrine unit is at ~280 m a.s.l., and where visible on the Crow River, overlies bedrock near river level at ~250 m a.s.l. Sediments are finely laminated, well indurated and comprised predominantly of silt. Neogene and older lacustrine sediments form a barrier to surface water drainage and may be ice rich themselves. This unit is prone to active-layer thaw detachment slides where it is exposed along the bluff above town.

D — **Weathered Bedrock (D):** The uplands surrounding and making up Berry Hill are uniformly mapped as 'weathered bedrock'. Weathered bedrock frequently contains silt in a matrix of blocks and boulders created through frost shattering, colluviation, and chemical weathering processes. Weathered bedrock typically contains a component of loess-derived silt and is subject to sorting and mixing from cryoturbation and other periglacial processes. Permafrost is present in both bedrock and weathered bedrock in the map area.

R — **Bedrock (R):** Bedrock in the map area consists of clastic and carbonaceous sedimentary rocks. The upper Neoproterozoic Katherine Formation in the map area is a mature, very fine grained, thin to thick-bedded, brown, greenish grey and white orthoquartzitic sandstone with minor recessive intervals of shale. Comprising Berry Hill and the gentle slopes below it, this distinctively white rock is the primary source for crush, rip-rap and other aggregate needs for the community of Old Crow. Lying unconformably below this unit is the dark grey siltstone and shale of the Jurassic-aged Porcupine River member of the Husky Formation which outcrops on the west bank of the lower Crow River just above the community of Old Crow.

LEGEND

GROUND OBSERVATION SITES:

- geological field station
- permafrost borehole (labelled with site number)

GEOLOGICAL FEATURES:

- nivation terrace
- landslide escarpment
- direction of landslide movement
- bedrock or surficial lineament

GEOLOGICAL BOUNDARIES:

- defined
- approximate
- assumed
- limit of mapping

TOPOGRAPHIC FEATURES:

- contours
- streams

SURFACE EXPRESSION

Surface expression refers to the form (assemblage of slopes) and pattern of forms expressed by a surficial material at the land surface. This three-dimensional shape of the material is equivalent to 'landform' used in a non-genetic sense (*e.g.*, ridges or plain). Surface expression symbols also describe the manner in which unconsolidated surficial materials relate to the underlying substrate (*e.g.*, veneer). Surface expression is indicated by up to three lower case letters, placed immediately following the surficial material designator, and is listed in order of decreasing extent.

a - apron: a wedge-like, slope-toe complex of laterally coalescent colluvial fans and blankets; longitudinal slopes are generally less than 15° (26%) from apex to toe with flat or gently convex/concave profiles

b - blanket: a layer of unconsolidated material thick enough (>1 m) to mask minor irregularities of the surface on the underlying material, but still conforms to the general underlying topography; outcrops of the underlying unit are rare

f - fan: sector of a cone with a slope gradient less than 15° (26%) from apex to toe; longtitudinal profile is smooth and straight, or slightly concave/convex

h - hummock: steep-sided hillock(s) and hollow(s) with multidirectional slopes dominantly between 15-35° (26-70%) if composed of unconsolidated materials, whereas bedrock slopes may be steeper; local relief >1 m; in plan, an assemblage of non-linear, generally chaotic forms that are rounded or irregular in cross profile; commonly applied to landslide debris.

p - plain: a level or very gently sloping, unidirectional (planar) surface with slopes 0-3° (0-5%); relief of local surface irregularities generally <1 m; applied to (glacio)fluvial floodplains, organic deposits, lacustrine deposits and till plains

t - terrace: a single or assemblage of step-like forms where each step-like form consists of a scarp face and a horizontal or gently inclined surface above it; applied to fluvial and lacustrine terraces and stepped bedrock topography

v - veneer: a layer of unconsolidated materials too thin to mask the minor irregularities of the surface of the underlying material; 10 cm - 1 m thick; commonly applied to eolian/loess veneers and colluvial veneers

w - mantle of variable thickness: a layer or discontinuous layer of variable thickness, typically 0 to 3 m, that fills or partly fills depressions in an irregular substrate; generally too thin to mask irregularities in the underlying material

GEOMORPHOLOGICAL PROCESSES

Geomorphological processes are natural mechanisms of weathering, erosion, and deposition that result in the modification of the surficial materials and landforms at the earth's surface. All processes are assumed to be active unless the qualifier "I" (inactive) is used. Up to three upper case letters may be used to indicate processes. These are listed in order of decreasing importance and placed after the surface expression symbol, following a dash (-) symbol.

Subclasses are used to provide more specific information about a general geomorophological process, and are represented by lower case letters placed after the related process designator. Up to two subclasses can be associated with each process. Process subclasses used on this map are defined with the related process below.

EROSIONAL PROCESSES

V - gully erosion: running water, mass movement, and/or snow avalanching, resulting in the formation of parallel and sub-parallel, long, narrow ravines

MASS MOVEMENT PROCESSES

L - mass movement at an unspecified rate including slow mass movements (downslope movement of masses of cohesive or non-cohesive surficial material and/or bedrock by creeping, flowing or sliding) and rapid mass movements (downslope movement by falling, rolling, sliding, or flowing of dry, moist, or saturated debris derived from surficial material and/or bedrock).

PERIGLACIAL PROCESSES

C - cryoturbation: movement of surficial materials by heaving and/or churning due to frost action (repeated freezing and thawing)

S - solifluction: slow gravitational downslope movement of saturated non-frozen overburden across a frozen or otherwise impermeable substrate

X - permafrost processes: processes controlled by the presence of permafrost, and permafrost aggradation or degradation

Z - general periglacial processes: solifluction, cryoturbation and nivation, possibly occuring in a single polygon

Subclasses: (t) thermokarst subsidence; (r) patterned ground;
(s) sheetwash; (w) ice-wedge polygons

HYDROLOGIC PROCESSES

U - inundation: terrain seasonally under standing water for greater than one month per year and resulting from a high watertable

BACKGROUND

Surficial geological mapping was undertaken for the community of Old Crow by the Yukon Geological Survey as part of the Old Crow Landscape Hazard Assessment: Geoscience mapping for Climate Change Adaptation Planning project. This project was a partnership between Yukon Geological Survey and the Northern Climate ExChange, Yukon Research Centre, Yukon College, and additional information including more detailed descriptions of surficial geology, can be found as part of the project report by Benkert, *et al*., 2016.

Previous mapping of surficial geology in the area is limited to regional reconnaissance mapping at a scale of 1:125 000 undertaken by the Geological Survey of Canada (Hughes *et al.*, 1973), and site-specific studies related to engineering and community development issues (*e.g.*, EBA, 2012). Updated mapping presented here incorporates recent imagery (satellite and LiDAR) and regional stratigraphic relationships to present geological information at a scale suitable for community development purposes.

METHODS

Surficial geological field mapping was completed for the study area at a scale of 1:10 000 during the summers of 2014 and 2015. Remote predictive mapping was completed using 1:40 000-scale 2002 digital monochrome aerial photographs with PurView/ArcGIS softcopy viewing software. LiDAR data acquired by Yukon Government in 2014 for part of the map area were also used to create a one-metre hillshade for detailed mapping where available. Historic geologic features in the map area, many of which have been subsequently obscured by anthropogenic development in the community, were mapped from monochrome and colour digital aerial photographs dating from 1951 (~1:70 000 scale), 1962 (1:40 000 scale), 1973 (1:12 000 scale) and 1988 (1:12 000 scale). Historic photos were also viewed and mapped using PurView/ArcGIS softcopy viewing software.

Field checking of units was completed by documenting anthropogenic and natural exposures of surficial materials, and by digging soil pits (up to ~1 m deep) in a broad range of surface sediments and landforms. Other new data incorporated include geophysical profiles of the subsurface (using ground-penetrating radar (GPR) and direct current electrical resistivity (ERT)), and new shallow boreholes. Previously acquired subsurface geological data were made available from borehole, test pits, and water well logs provided by EBA Engineering Consultants Ltd. (R. Trimble, Tetra Tech EBA, pers. comm., 2010).

ACKNOWLEDGEMENTS

This map was produced as part of a community hazards mapping program coordinated by Bronwyn Benkert from the Northern Climate ExChange, Yukon Research Centre, Yukon College. Surficial geology mapping for the community of Old Crow was undertaken by Kristen Kennedy, with field data and collaboration from Panya Lipovsky (YGS) and Jack Dennett (EBA). Assistance in the field in 2015 was provided by Joshua Weibe. Site specific permafrost investigations were conducted by Louis-Philippe Roy (Yukon Research Centre), Kate Grandmont (University of Montreal), Antoni Lewkowicz (University of Ottawa), and Daniel Fortier (University of Montreal). Funding for this project was provided by Canadian Northern Economic Development Agency's (CanNor) Strategic Investments in Northern Economic Development (SINED) program. Vuntut Gwitchin Government and the Vuntut Gwitchin First Nation are gratefully acknowledged for their support and participation in this project.

RECOMMENDED CITATION

Kennedy, K.E., 2016. Surficial geology, Old Crow, Yukon; parts of NTS 116O/12. Yukon Geological Survey, Energy, Mines and Resources, Government of Yukon, Open File 2016-16, 1:10 000 scale.

Any revisions or additional geological information known to the user would be welcomed by the Yukon Geological Survey.

Paper copies of this map may be obtained from Yukon Geological Survey, Room 102 - 300 Main St., Whitehorse, Yukon, Y1A 2B5.
Phone: 867-667-3201, E-mail: geology@gov.yk.ca.

A digital PDF (Portable Document Format) file of this map may be downloaded free of charge from the Yukon Geological Survey website: http://www.geology.gov.yk.ca.

SELECTED REFERENCES

Benkert, B.E., Kennedy, K., Fortier, D., Lewkowicz, A., Roy, L.-P., de Grandpré, I., Grandmont, K., Drukis, S., Colpron, M., Light, E. and Williams, T. 2016. Old Crow landscape hazards: Geoscience mapping for climate change adaptation planning. Northern Climate ExChange, Yukon Research Centre, Yukon College. 136 p. and 2 maps.

Duk-Rodkin, A. and Hughes, O.L., 1995. Quaternary geology of the northeastern part of the central Mackenzie Valley Corridor, District of Mackenzie, Northwest Territories. Geological Survey of Canada Bulletin, 458, 45 p.

EBA Tetra Tech Company, 2012. Old Crow Landslide Assessment, Impacts and Recommendations. Unpublished report prepared for the Vuntut Gwitchin Government, June, 2012, 16 p.

Howes, D.E. and Kenk, E., 1997. Terrain Classification System for British Columbia (Version 2). Recreational Fisheries Branch, Ministry of Environment and Surveys and Resource Mapping Branch, Ministry of Crown Lands, Province of British Columbia, Victoria, BC, 102 p.

Hughes, O.L., 1972. Surficial geology of northern Yukon Territory and northwestern District of Mackenzie, Northwest Territories. Paper 69-36, Geological Survey of Canada, Department of Energy, Mines and Resources, 11 p. (1 map sheet).

Hughes, O.L., Pilon, J., Veillette, J.J., Zoltai, S.C. and Pettapiece, W.W., 1973. Surficial Geology and Geomorphology of Old Crow (NTS 116O and 116N-east). Geological Survey of Canada Open File 167, 1 map sheet (unedited manuscript, scale: 125,000).

Kennedy, K.E., Froese, D.G., Zazula, G.D. and Lauriol, B., 2010. Last Glacial Maximum age for the northwest Laurentide maximum from the Eagle River spillway and delta complex, northern Yukon. Quaternary Science Reviews, vol. 29, p. 1288-1300.

Kokelj, S.V. and Joergenson, M.T., 2013. Advances in thermokarst research. Permafrost and Periglacial Processes, vol. 24, p. 108-119.

Lewkowicz, A.G., 2007. Dynamics of active-layer detachment failures, Fosheim Peninsula, Ellesmere Island, Nunuvut, Canada. Permafrost and Periglacial Processes, vol. 18, p. 89-103.

Schweger, C.E., 1989. The Old Crow and Bluefish Basin, Northern Yukon: Development of the Quaternary History. *In*: Late Cenozoic History of the Interior Basins of Alaska and the Yukon, D.L. Carter, T.D. Hamilton and J.P. Galloway (eds.),U.S. Geological Survey Circular, vol. 1026, p. 30-33.

Thornson, R.M. and Dixon, E.J., 1983. Alluvial history of the Porcupine River, Alaska: Role of glacial-lake overflow from Northwest Canada. Geological Society of America Bulletin, vol. 94, no. 5, p. 576-589.

Zazula, G.D., Duk-Rodkin, A., Schweger, C.E. and Morlan, R.E., 2004. Late Pleistocene chronology of glacial Lake Old Crow and the north-west margin of the Laurentide Ice Sheet. *In*: Quaternary Glaciations – Extent and Chronology, J. Ehlers and P.L. Gibbard (eds.), Part II, p. 347-362.

Open File 2016-16

Surficial Geology, Old Crow, Yukon
Parts of NTS 116O/12
1:10 000 scale

by

K.E. Kennedy

Yukon Geological Survey
Energy, Mines and Resources
Government of Yukon