Figure 3. A view to the west of the middle reaches of Grayling Creek in the northwest corner of the map area. Grayling Creek occupies a glacial diversion through this area. Linear moraine ridges are apparent on the hillside to the left of the creek. Despite occupying a glacial diversion channel, placer gold grains were still obtained from creek bar samples. See results for 08-JB-086 in the marginal notes.

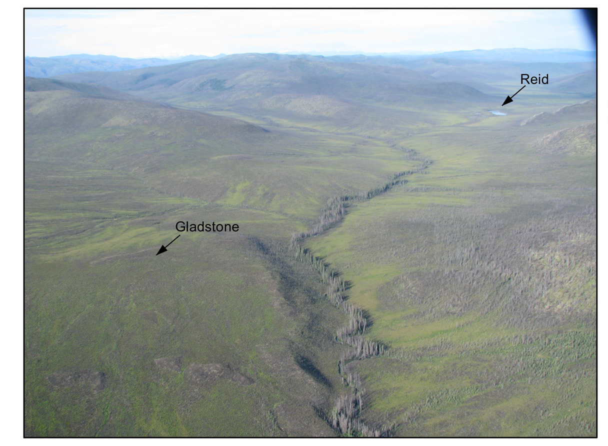


Figure 4. A view to the west along the eastern margin of the map area. The valley bottom is underlain by subdued Reid and Gladstone moraine deposits (see arrows). The lake in the background marks the limit of the Reid glaciation.

MARGINAL NOTES

PHYSIOGRAPHY AND DRAINAGE

115J/03 map area lies within the Nisling Range and is characterized by a rolling, largely unglaciated dissected plateau surface (Fig. 1 and 2). The Nisling River cuts across the northeast corner and is fed by east-flowing unnamed tributaries within the map area. The headwaters of Grayling Creek are located in the south and a glacially diverted reach of the creek flows across the northwest corner of the area (Fig. 3). The highest summit in the map area is Mount Forrest (1560 m elevation) and the majority of summits reach 1220 m elevation. The lowest elevation in the map area is the Nisling River at 600 m. Upper Grayling Creek valley has a mature landscape appearance with broad gentle slopes, which are somewhat unique in the Nisling Range (Fig. 2). This type of physiography suggests a stable weathering environment with little to no recent tectonic disruption.

SURFICIAL GEOLOGY

115J/03 map area is predominantly unglaciated with the exception of glaciated terrain along the eastern and southern margins. The unglaciated surficial deposits consist of weathered bedrock colluvium, fluvial deposits, eolian deposits, and organic material. At the highest elevations, on summits and ridge tops, the surficial deposits consist of locally weathered bedrock that has undergone minimal gravitational transport. Slope deposits consist of colluviated weathered bedrock veneers and blankets that have textural properties reflecting the local bedrock lithologies. Aeolian additions into the soil profiles may be significant, especially near the Nisling River (Fig. 1).

The map area lies at the northern limit of glaciation by the Cordilleran Ice Sheet. Three glacial limits have been mapped and are correlated with the Reid (120 ka), Gladstone (60 ka) and McConnell (15 ka) glaciations. The ice extent was greatest during the Reid glaciation and least extensive during the McConnell glaciation. In the Nisling River valley, approximately 10 km separates the Reid and McConnell glacial limits, whereas near the southern edge of the map area the difference is only 0.5 - 1 km. The main conduits for ice along the eastern margin of the map area were Onion Creek and Nisling River valleys. This ice front would have blocked eastward drainage from the interior of the map area and caused northward drainage diversions and possibly deposition of glaciolacustrine sediments. Subdued and moraine deposits are preserved from the Reid glaciation in this area and broad outwash plains are present in the Nisling River valley (Fig. 4). Along the southern margin of the map area the ice advanced to edge of the Grayling Creek drainage. The headwaters of three tributaries to Grayling Creek were overtopped by the ice allowing meltwater to flow into the drainage. In the southwest the ice was sufficiently thick during the Reid glaciation to reach Grayling Creek and deposit an end moraine. The pulses of meltwater draining into the Grayling Creek valley caused erosion within the tributaries and establishment of a lower base level. Remnant high-level fluvial terraces are present on the south side of the valley that pre-date the Reid glaciation and may date to the Tertiary.

PERMAFROST

Evidence of permafrost was found at all elevations in the map area. Thermokarst lakes are particularly common, likely due to the abundance of loess that has accumulated in the valleys. Inactive areas of the Nisling River floodplain are also underlain by permafrost. This is particularly obvious by the lack of tree growth on large areas of the floodplain. Periglacial features such as solifluction and nivation terraces are common near the higher uplands in the Nisling Range.

PLACER POTENTIAL

The placer potential of Grayling Creek is described in Bond et al. (2008) and is expanded upon by this surficial geology map and Brochure 2015-1. Paleo-Grayling Creek fluvial gravel benches have been mapped in the headwaters of the drainage. Colluvial aprons overlie the bench gravel and permafrost is pervasive, therefore tests could not be conducted on the bench edges where overburden is thin. The presence of placer gold has not been confirmed in the pre-glacial benches however, surface sampling at multiple locations on the Grayling Creek floodplain consistently produced gold grains. Importantly, only one floodplain sample site (08-JB-096) was located near the pre-glacial benches and it is described in the Heavy Mineral table below. Three placer deposit models are proposed for exploring Grayling Creek:

1) Pre-glacial (Tertiary?) bench deposits in the upper reaches of the drainage. Placer gold, if present, will be concentrated near the bedrock surface and may be preferentially enriched in channels;

2) Modern stream fluvial deposits created after the Reid glaciation-related base level adjustments. Placer gold will be disseminated throughout the fluvial gravel but may have greater concentration on the bedrock surface. These will be immature placers so channelized placer distribution is less of a concern; and

3) Gulch deposits, in tributaries to Grayling Creek, created within or near the glacial diversion sections of the drainage. Placer gold, if present, will be concentrated on the bedrock surface.

HEAVY MINERAL SAMPLING

Site Number	Location (UTM Zone 7)	Type	Results
07JB059	594641 E / 6901731 N	bulk Heavy Min	1 gold grain
07JB060	600420 E / 6895623 N	bulk Heavy Min	3 gold grains, 1 ruby corundum
		sluice (7.5 gallons)	No gold grains
08JB072	580675 E / 6898056 N	sluice (7.5 gallons)	3 gold grains (2 reshaped, 1 pristine)
08JB073	580612 E / 6898138 N	pan (x1)	No gold observed
08JB086	578397 E / 6899211 N	sluice (7.5 gallons)	6 gold grains (5 reshaped, 1 pristine)
08JB096	580116 E / 6883164 N	sluice (7.5 gallons)	7 gold grains (7 reshaped)

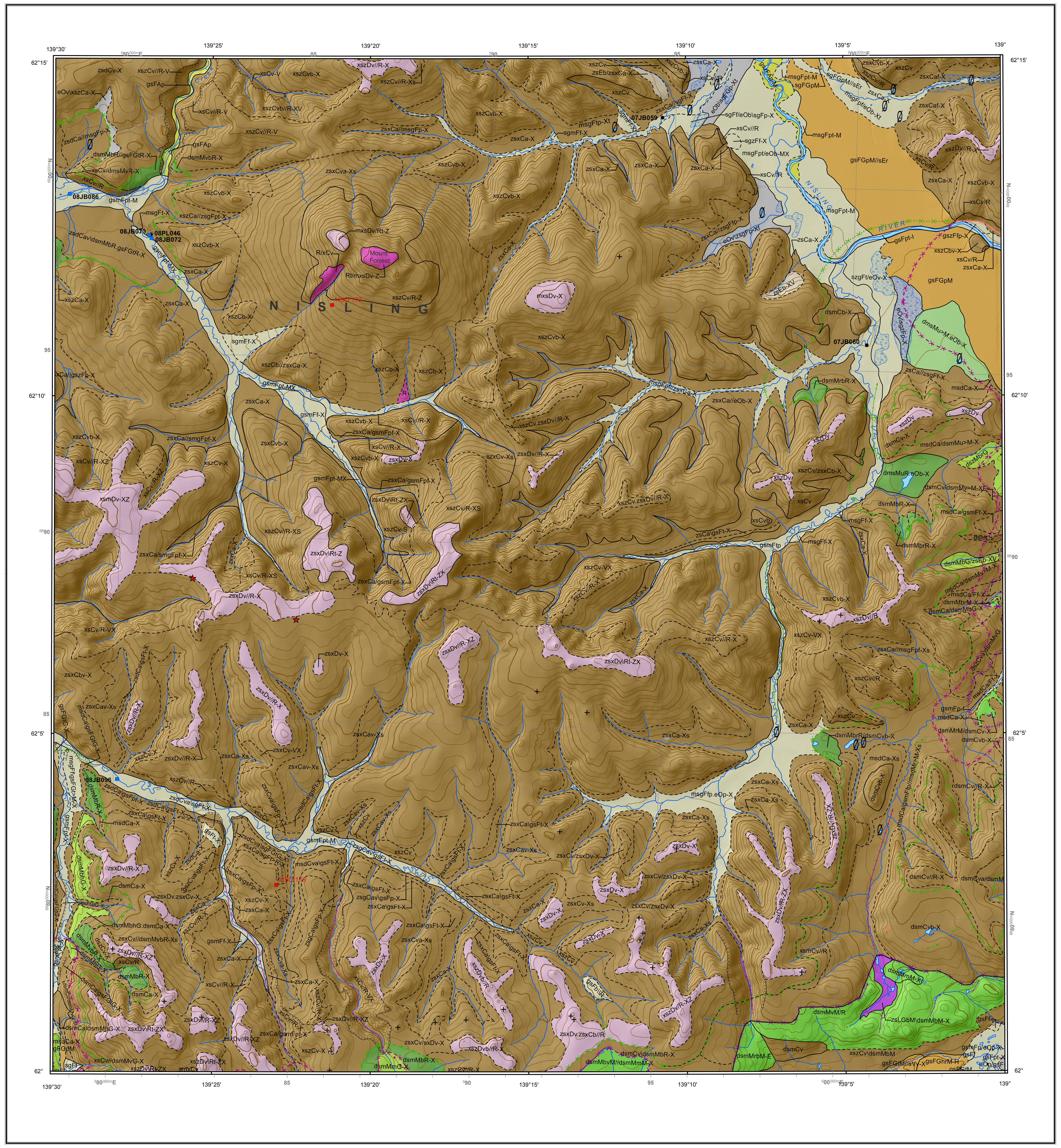
DATA SOURCES

This surficial geology map was interpreted from high resolution digital stereo imagery (1:40000 scale scanned aerial photographs flown in 1989*). Selective field checking was performed in July 2007 and July 2008.

*National Air Photo Library photographs A27479: 49-58, 81-90, 119-129, 178-186.

Figure 1. A view of a headwater environment in a tributary to Grayling Creek. Most of the upland environments are forest covered with the exception of the highest ridges and peaks. The slopes in this valley are underlain by weathered bedrock colluvium. The valley contain fluvial gravel deposits and colluvial aprons of weathered bedrock, loess and organics.

Figure 2. View to the southeast of a large unnamed tributary valley to Grayling Creek that illustrates the physiography. Broad valleys, characteristic of a mature landscape, are common in the map sheet. Glacial activity near the margins of the map sheet have disrupted stream base-levels causing erosion to occur. High-level fluvial terraces (see arrow) are common in Grayling Creek and some of its tributaries.



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

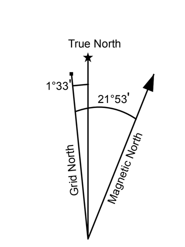
FIVE THOUSAND METRE GRID
Universal Transverse Mercator Projection
North American Datum 1983
Zone 7

CONTOUR INTERVAL 100 FEET
Elevations in feet above Mean Sea Level

SURFICIAL GEOLOGY
115J/03
YUKON

SCALE 1:50 000

kilometres



Use diagram only to obtain numerical values
APPROXIMATE MEAN DECLINATION NOVEMBER 2011
FOR CENTRE OF MAP

115J/05 WELLESLEY LAKE open file 2013-9	115J/06 open file 2013-10	115J/07 MOUNT PATTISON open file 2013-11
115J/04 MACKINNON CREEK open file 2013-4	115J/03 open file 2015-5 MAP LOCATION	115J/02 ONION CREEK open file 2013-8
115G/13 TOM MURRAY CREEK GSC map 7-1978	115G/14 TOSHINGERMANN LAKES open file 2009-45	115G/15 KIYERA LAKE open file 2009-46

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 = sheetflow)
- 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

SURFICIAL MATERIALS

Surficial materials are non-lithified, unconsolidated sediments. They are produced by weathering, sediment deposition, biological accumulation, human and volcanic activity. In general, surficial materials are of relatively young geological age and they 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

O — Organic: Organic deposits are accumulations of vegetative matter thicker than 1 m. They are commonly found in floodplains, areas of near-surface permafrost such as north-facing slopes, and locations where there is poor drainage. Thin veneers of organic material are widespread and generally unmapped. Organic material in the map area commonly consists of peat with fibric to mesic decomposition.

E — Eolian: 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. Loess veneers and blankets were deposited over the landscape during the last (McConnell) glaciation. On stable sites, the loess is intact, whereas in cryoturbated or colluviated areas, the loess is reworked into the soil profile and its presence is indicated by the "z" textural symbol. Resedimented loess is a major component of colluvial aprons in the area. Ice-rich permafrost is common within low-lying eolian sediments.

C — Colluvium: Material transported and deposited by down-slope, gravity-driven processes such as creep, solifluction, landslides and snow avalanches. Colluvium is the dominant surficial material in the region as most of the area escaped Pleistocene glaciation. 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 slopes is generally derived from weathered bedrock and loess, resulting in a silt-rich diamicton colluvium. In particular, local bedrock clasts. On steeper slopes colluvium is generally coarser grained, as it has been deposited by rapid mass wasting processes such as rock falls, debris flows and avalanches. Slower processes such as sheetwash, solifluction and creep occur on gentler slopes and produce finer grained colluvium. Colluvial aprons found on lower slopes are commonly ice-rich and are primarily composed of resedimented loess and peat.

F, FA — Fluvial: 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 sub-angular to rounded clasts. In unglaciated regions, low order streams are confined to very narrow V-shaped valleys and their fluvial deposits are generally not mapped due to scale limitations; their sediments, however, are more coarse grained and more locally derived than in higher order streams. Active fluvial (FA) materials are subject to regular flooding. Pre-glacial fluvial terraces are present in Grayling Creek.

Glaciofluvial: Sediments transported and deposited by glacial meltwater above, in, below, or adjacent to a glacier. Glaciofluvial materials are deposited in meltwater channels, eskers, plains, terraces, kames and deltas. Sediments consist of moderately to well-sorted, rounded, stratified sand and gravel, although the nature and texture may vary locally depending on transport distance. Near surface ground ice is generally absent in glaciofluvial deposits unless there is a poorly drained underlying unit present.

- FG^M — LATE WISCONSIN - McCONNELL (M)
- FG^G — EARLY WISCONSIN - GLADSTONE (G)
- FG^R — ILLINOIAN - REID (R)
- $FG^{>R}$ — EARLY PLEISTOCENE - PRE-REID (>R)

Morainal: Morainal (till) materials are diamicts deposited by either: primary glacial processes such as lodgement, deformation and melt-out (ablation); or secondary glacial processes caused by gravity and water. Therefore, this term applies to all types of till including flow tills, which are not directly deposited by glacial ice. Ablation tills are relatively coarse grained and tend to have a hummocky or rolling surface expression; lodgement tills typically have a finer grained matrix with fewer clasts and a smoother surface expression. Tills are generally colluviated when found on slopes. Permafrost is widespread within morainal deposits. As most of the region is unglaciated, morainal sediments are limited to deposits along the eastern and southern margins of the map sheet. Landform preservation will vary depending on the age of deposition.

- M^M — LATE WISCONSIN - McCONNELL (M)
- $M^{>M}$ — PRE-LATE WISCONSIN - McCONNELL (>M)
- M^G — EARLY WISCONSIN - GLADSTONE (G)
- M^R — ILLINOIAN - REID (R)
- $M^{>R}$ — EARLY PLEISTOCENE - PRE-REID (>R)

LG — Glaciolacustrine: Stratified sand, silt and clay deposited in a lake that formed on, in, under or beside a glacier; may contain dropstones (ice-rafted clasts). Ice-rich permafrost and thermokarst erosion is widespread in these deposits as they are generally poorly drained with high *in situ* moisture contents that promote the growth of massive ice lenses. Glaciolacustrine sediments are rarely exposed in the region.

PRE-QUATERNARY

R — Bedrock: Bedrock in the northern and eastern parts of this map area consists of Devonian-Mississippian carbonaceous muscovite-quartz phyllite or schist and quartzite of the Yukon-Tanana terrane. Cretaceous-Tertiary Donjek volcanics underlie Mount Forrest (primarily olivine basalt) and the terrain immediately to the west (rhyolite) and south (dacite) (Murphy et al., 2007, 2008).

D — Weathered bedrock: bedrock decomposed or disintegrated *in situ* by processes of chemical and/or mechanical weathering, such as freeze-thaw. Weathered bedrock is common on unglaciated uplands, especially along ridge tops and near tors. The material texture is coarse grained and sandy where derived from plutonic bedrock, although a silty component may be present due to incorporation of loess by cryoturbation.

SYMBOLS

GEOLOGICAL BOUNDARIES:
- defined
- approximate
- assumed

AGE OF GLACIAL FEATURES:
- McConnell (M) - late Wisconsin
- Gladstone (G) - early Wisconsin
- Reid (R) - Illinoian
- Pre-Reid (>R) - early to middle Pleistocene
- age unspecified

GLACIAL FEATURES:
- moraine ridge
- meltwater channel
- cirque
- arete

GLACIAL LIMITS:
- defined
- approximate
- assumed

OTHER LINEAR FEATURES:
- escarpment
- lineation (fault, joint, tension crack)
- sand dunes
- strandline

TOPOGRAPHIC FEATURES:
- contours
- streams
- trails
- wetlands

GROUND OBSERVATION SITES:
(labelled with site number, e.g. 10JB004)
- field station
- stratigraphic section
- radiocarbon sample
- cosmogenic sample
- heavy mineral sample
- erratic, unspecified age
- erratic, Gladstone
- erratic, Reid
- no erratics found

OTHER SURFACE FEATURES:
- open system pingo; uncollapsed, collapsed
- tor
- drumlin (coloured by glacial age)
- cryoplanation terrace
- kettle
- landslide, active layer detachment
- palsa
- thermokarst pond
- placer mine
- Yukon mineral occurrence

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 between >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
o - organic: general organic materials
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

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, 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, 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 of the underlying material, but still conforms to the general underlying topography; outcrops of the underlying unit are rare

c - cone: a cone or sector of a cone, mostly steeper than 15° (26%); longitudinal profile is smooth and straight, or slightly concave/convex; typically applied to talus cones

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 knob-and-kettle glaciofluvial terrain

l - delta: landform created at the mouth of a river or stream where it flows into a body of water; gently sloping surfaces between 0-3° (0-5%), and moderate to steeply sloping fronts between 16-35° (27-70%); glaciofluvial deltas in the map area are typically coarse-grained with steep sides and gently inclined kettled or channeled surfaces

m - rolling: elongate hillock(s); slopes dominantly between 3-15° (5-26%); local relief >1 m; in plan, an assemblage of parallel or sub-parallel linear forms with subdued relief (commonly applied to bedrock ridges and fluted or streamlined till plains)

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

r - ridge: elongate hillock(s) with slopes dominantly 15-35° (26-70%) if composed of unconsolidated materials; bedrock slopes may be steeper; local relief is >1 m; in plan, an assemblage of parallel or sub-parallel linear forms; commonly applied to drumlinized till plains, eskers, morainal ridges, crevasse fillings and ridged bedrock

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 - 1m thick; commonly applied to eolian/loess veneers and colluvial veneers

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. Unless a qualifier (A (active) or I (inactive)) is used, all processes are assumed to be active, except for deglacial processes. 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 letter(s) 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

FLUVIAL PROCESSES

B - braiding channel: active floodplain consists of many diverging and converging channels separated by unvegetated bars

I - irregularly sinuous channel: a clearly defined main channel displaying irregular turns and bends without repetition of similar features; backchannels may be common, and minor side channels and a few bars and islands may be present, but regular and irregular meanders are absent

J - anastamosing channel: a channel zone where channels diverge and converge around many islands. The islands are vegetated and have surfaces that are far above mean maximum discharge levels

M - meandering channel: a clearly defined channel characterized by a regular and repeated pattern of bends with relatively uniform amplitude and wave length

MASS MOVEMENT PROCESSES

F - slow mass movements: slow downslope movement of masses of cohesive or non-cohesive surficial material and/or bedrock by creeping, flowing or sliding

L - mass movement with an unspecified rate

R - rapid mass movements: rapid downslope movement by falling, rolling, sliding or flowing of dry, moist or saturated debris derived from surficial material and/or bedrock

Subclasses: (b) rockfall; (d) debris flow; (g) rock creep; (s) debris slide; (u) slump in surficial material

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: (e) thermokarst erosion; (f) thaw flow slides; (l) segregated ice; (n) pingo; (t) thermokarst subsidence; (r) patterned ground; (s) sheetwash; (w) ice-wedge polygons

DEGLACIAL PROCESSES

E - channeled by meltwater: erosion and channel formation by meltwater alongside, beneath, or in front of a glacier

H - kettled: depressions in surficial materials resulting from the melting of buried glacier ice

T - ice contact: landforms that developed in contact with glacier ice such as kames

SURFICIAL MATERIAL AGE

GLACIATION	TIME PERIOD	APPROXIMATE GLACIAL MAXIMUM	MARINE ISOTOPE STAGE
M - McConnell	late Wisconsin	15 000 years ago	2
G - Gladstone	early Wisconsin	55 000 years ago	4
R - Reid	Illinoian	130 000 years ago	6
>R - Pre-Reid	early to Middle Pleistocene	2.6 million to 200 000 years ago	8-102

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RECOMMENDED CITATION

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

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Yukon Geological Survey
Energy, Mines and Resources
Government of Yukon

Open File 2015-5

Surficial Geology NTS 115J/03 Yukon (1:50 000 scale)

by

Jeffrey D. Bond and Panya S. Lipovsky