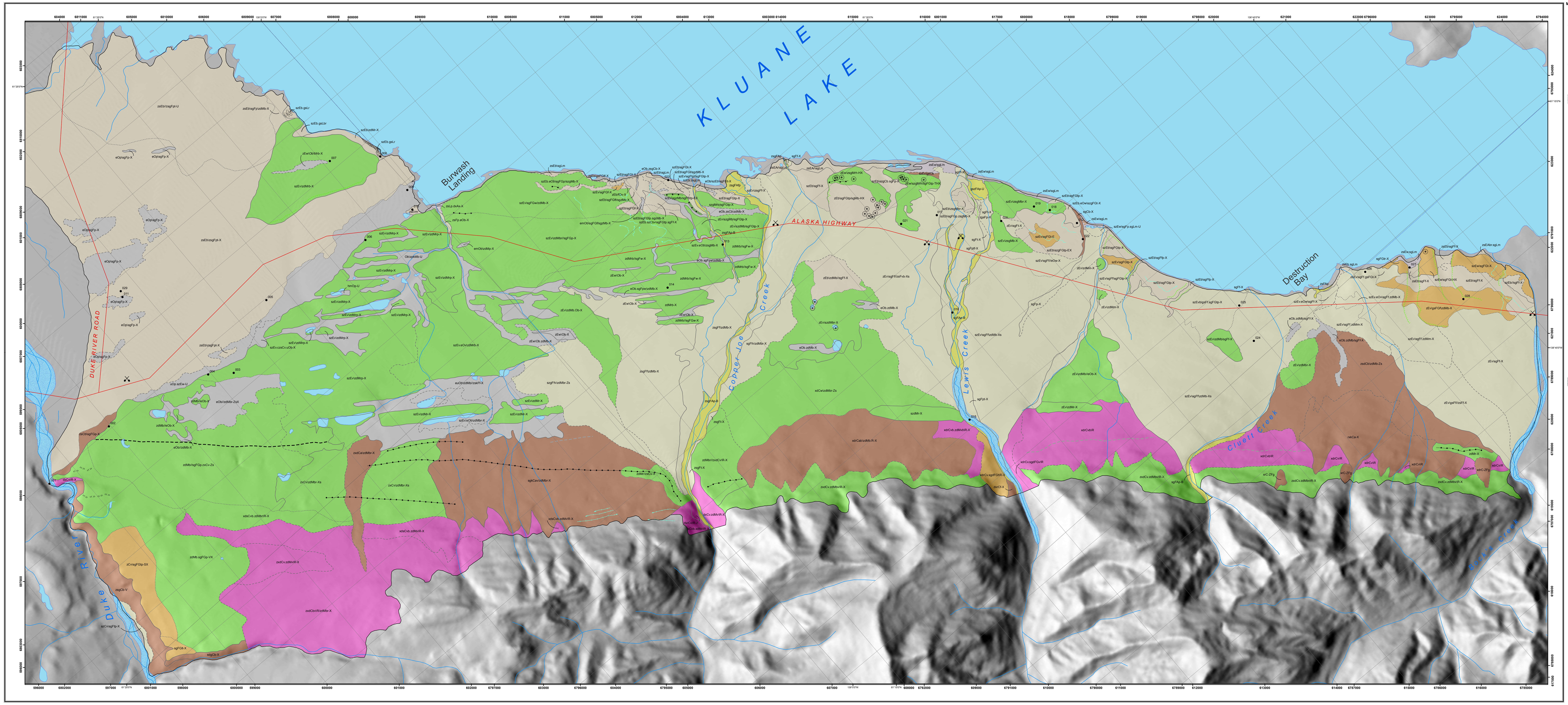


MARGINAL NOTES

The map area occupies a northwest-trending valley in a broad physiographic region known as the Shakwak Trench. The Shakwak Trench is a structurally controlled longitudinal valley and represents the surface expression of the Denali Fault, which runs from Haines, Alaska, to the south end of Kluane Lake to eastern Alaska. It separates the tectonically active rugged mountains to the west (the Kluane Range) from the lower mountains and broad valleys east of the fault (the Ruby Range). The Kluane Range, which form part of the St. Elias Mountains, rise steeply above the Shakwak Trench as a narrow band of glaciated peaks. Topographic relief in the Kluane Range is in excess of 1600 m and the mountain front to the west of the study area has an average slope of about 30-40 degrees. Drainage in the southern Shakwak Trench is southwest to the Alsek River and Pacific Ocean, while drainage in the northern part of the trench (where this map area is located) is north toward the Yukon River and ultimately the Bering Sea. Permafrost is widespread in the Shakwak Valley northwest of Kluane Lake.

Surficial materials:
The Shakwak Valley comprises a gently undulating and glacially fluted floor underlain by thick deposits of till, lacustrine silts and outwash from a number of glaciations, as well as Holocene alluvium and loess (Denton and Stuiver, 1967; Rampton, 1969). Along the base of the mountain front of the Kluane and Ruby Ranges, colluvial aprons and fans grade into broad alluvial fans and aprons (Figures 1 and 2). Surficial materials in the study area are derived from glacial, fluvial, lacustrine, colluvial, eolian and organic processes. Each process, or combination of processes, forms distinct materials that can be characterized based on the grain size, sorting, structure, and general distribution of the material. Detailed descriptions of the surficial materials found in the study area are located in the map legend.

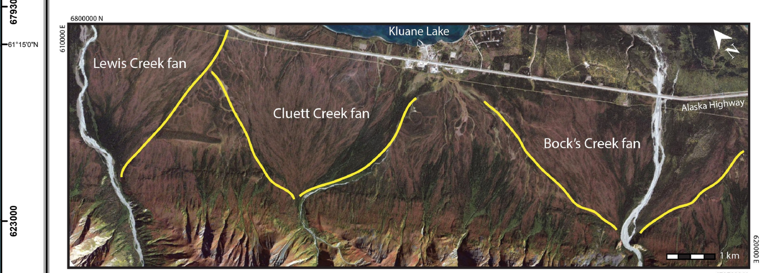


Figure 1. Alluvial fans built out of the Kluane Range onto the Shakwak Valley floor are a significant feature of the map area.

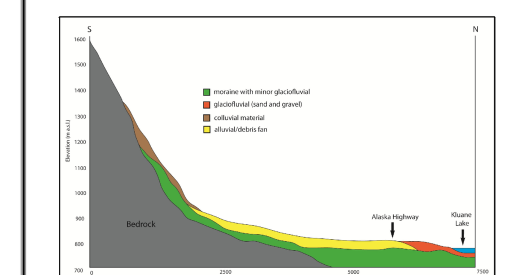


Figure 2. Simplified cross-valley profile of the map area.

Glacial History:
Several periods of glaciation occurred in the region during the Quaternary Period (~2 My-10 ka BP), the latest being the late-Wisconsin (*ca.* 22 ka BP) Kluane Glaciation (Denton and Stuiver, 1967). While early and middle Pleistocene glacial and interglacial periods are believed to be preserved in some sediment records in the region (Rampton, 1981), only evidence of the most recent Kluane Glaciation is well-preserved in the study area. Ice flow during the Kluane Glaciation was generally out of ice centres in higher mountainous areas, such as the St. Elias, Coast, and Cassiar mountains, and along major structural trenches and valleys.
During the Kluane Glaciation, ice flowed out of the valleys of the St. Elias Mountains and extended northwest along the Shakwak Trench and into the Ruby Range (Figure 3; Duk-Rodkin, 1999). Most of the uplands in the Ruby Range remained ice-free during this glaciation, although glacial features in the southern part of the range suggest it did support cirque glaciers and local ice caps.
During the waning stages of the Kluane Glaciation, valley glaciers may have been out of synch with glaciers in main tributary valleys, impounding lakes and forming large glaciofluvial complexes in alpine valleys. Major glacial lakes likely also formed within the Shakwak Trench (Rampton, 1981), although little evidence of their existence is preserved.
The immediately post-glacial period in the map area was marked by widespread landslide activity and loess deposition. Glacially over-steppened slopes and abundant glacial material deposited along valley sides could be readily mobilized into the valley bottom where sparse vegetation cover and local katabatic winds would have created favourable conditions for loess deposition.
Neoglacial advances have occurred numerous times in the past ~2800 years in the Kluane Icefields. The most recent neoglacial advance likely took place ~450 years ago and was responsible for an advance of the Kaskawulsh Glacier that led to a high stand of Kluane Lake (Rampton, 1981). Repeated variations in the level of Kluane Lake throughout the neoglacial period have been attributed to changes in base level in the Slims and Kaskawulsh valleys (Bostock, 1969; Clague, 1981).

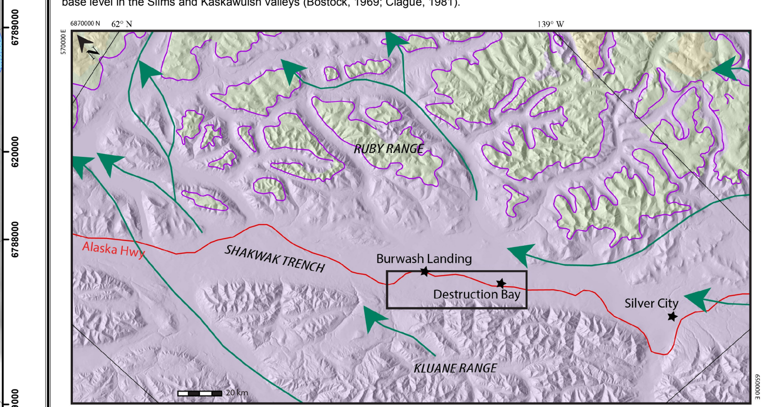


Figure 3. Purple shading outlines the extent of the late-Pleistocene Kluane Glaciation in the map area. Green arrows indicate general regional ice flow directions.

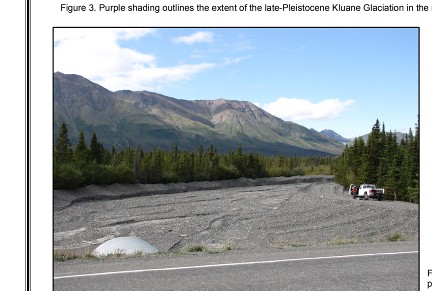
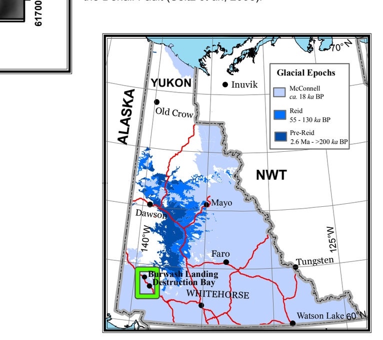


Figure 4. An example of berms on Bock's Creek that serve to mitigate potential debris floods and flows.

Geologic Hazards:
Debris flows and debris slides are the most common types of mass movements in the Shakwak Valley (Clague, 1981; Huscroft *et al.*, 2004) and are generally triggered by intense rainfall events on steep to moderate colluvial or till-covered slopes.
In a study of debris fans along the Alaska Highway corridor, Koch *et al*. (in press) demonstrate that fans in the study area were largely active during and immediately after deglaciation. Small debris flow and flood events were recorded; however, none were significant on lower fan surfaces (where infrastructure is located). Furthermore, the authors conclude the axial streams of all the fans in the study area have been modified to such a degree by large-diameter culverts, levees and berms (*e.g*. Figure 4) that any future debris flows will likely be restricted to present stream crossings of the Alaska Highway corridor (Koch *et al*., in press).
Paleoseismic results from a site near Burwash Landing suggest that at least three large magnitude surface faulting earthquakes have occurred along the Yukon section of the Denali Fault in the past 3800 years, with an average recurrence interval of approximately 1000 years (Seitz *et al*., 2008). Activity on this fault can include significant ground ruptures (3-4 m displacements) and deformation of surface sediments. Surface offsets of nearby geomorphic features suggest a late Pleistocene-Holocene slip rate of 2-4 mm/yr along this portion of the Denali Fault (Seitz *et al*., 2008).

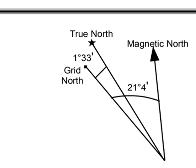


115G/11 NUNTAEA CREEK	115G/10 SERPENTHEAD CREEK	115G/09 TALBOT CREEK
115G/06 DUKE RIVER	115G/07 [illegible]	115G/08 GLADSTONE CREEK
115G/03 BIGHORN CREEK	115G/02 [illegible]	115G/01 CULTUS CREEK

SURFICIAL GEOLOGY
BURWASH LANDING AND DESTRUCTION BAY
YUKON
parts of NTS 105G/2, 6 and 7

SCALE 1:20 000

0 0.25 0.5 1 1.5 2
kilometres



Use diagram only to obtain numerical values
APPROXIMATE MEAN DECLINATION
MARCH 2013 FOR CENTRE OF MAP

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

ONE THOUSAND METRE GRID
Universal Transverse Mercator Projection

CONTOUR INTERVAL 100 FEET
Elevations in feet above Mean Sea Level

SURFICIAL GEOLOGY MAP

This surficial geology map was classified using the Terrain Classification System for British Columbia (Howes and Kenk, 1997), with modification to meet standards set by the Yukon Geological Survey. For example, we have added permafrost process subclasses to further account for the breadth of permafrost features on the landscape. Linework for the map was produced from interpretations of 1:40 000 and 1:20 000-scale aerial photos (flown from 1985 through 1989). Subsequent field checking of the map area was completed in the summer of 2012.

Terrain Classification

1st terrain unit (50-100% of map unit) / 2nd terrain unit (30-49% of map unit) // 3rd terrain unit (10-29% of map unit)

Overlying terrain unit (50-100% of map unit) \ Underlying terrain unit

/ discontinuous covering of material / 2nd terrain unit

sgFGpt-Xs
- geomorphological process(es) (permafrost - X) subclass(es) (sheetflow - s)
- surface expression (plain, terrace)
- qualifier (glacial, active)
- surficial material (fluvial)
- texture (sand, gravel)

SURFICIAL MATERIAL

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. On the map, surficial materials form the core of the polygon label. They are symbolized with a single upper case letter, with texture written to the left, and surface expression or glacial qualifier to the right. The glacial qualifier "G" is used to describe glacially modified materials. If actual activity state is different than the assumed activity state (indicated in brackets next to the surficial material name below), a qualifier A (active) or I (inactive) must be used as a superscript following the surficial material designator. Note that a single polygon will be coloured only by the dominant surficial material, but other materials may exist in that unit.

C — Colluvium (active): Colluvial deposits include materials that have reached their present positions as a result of direct, gravity-induced movement involving no agent of transportation such as water or ice (Howes and Kenk, 1997). Colluvial deposits in the map area generally consist of massive to moderately well-stratified, non-sorted to poorly-sorted sediments with any range of particle sizes from clay to boulders. Colluvial deposits commonly form near the bottom of moderate to steep-slopes, where materials have been moved downslope due to gravity. Colluvial deposits in the map area occur along steep stream-cut escarpments, as well as along the steep to moderately sloping flanks of the Kluane Range. Colluvial deposits are gravity-modified versions of pre-existing deposits, and as such, are reflective of regional deposit types. Colluvial deposits along stream-cut escarpments in the map area are typically composed of mixed glacial, glaciofluvial and fluvial materials while mountain front colluvial deposits are commonly characterized by mixed rock fragments and glacial diamict deposits. A small number of rock glaciers occur in the map area and are classified as colluvial landforms. On north and east-facing aspects colluvial deposits are likely to be affected by permafrost.

E — Eolian (inactive): Eolian deposits include materials transported and deposited by wind. These deposits generally consist of medium to fine sand and coarse silt that is well-sorted, non-compacted, and may contain internal structures such as cross-bedding or ripple laminae, or may be massive (Howes and Kenk, 1997). Much of the map area is covered with a veneer of wind-deposited silt and fine sand, with less extensive areas of thick eolian deposits. Active landforms such as fluvial channels or colluvial fans are unlikely to have noticeable accumulations of eolian deposits. Modern (active) eolian deposition is limited to isolated deposits of sand and silt along the shore of Kluane Lake. Inactive, silt-rich eolian deposits are commonly affected by permafrost and may be ice-rich.

F — Fluvial (inactive): Fluvial deposits are materials that have been transported and deposited by streams and rivers. Fluvial sediments in the map area are predominantly those comprising the floodplains and fans of streams draining the Kluane Range. These deposits generally consist of stratified beds of gravel and/or sand with sand and/or silt and/or organic materials (and rarely clay). Gravels are typically rounded and contain interstitial sand. These deposits are commonly moderately to well-sorted and display stratification. Silt, sand, and organic deposits make up thinly laminated or massive overbank deposits that are commonly interbedded with coarser gravel deposits. Fine-grained lenses and beds in these fluvial deposits may contain ice, although it may be discontinuous over relatively small areas. Active fluvial channels (discussed below)

FA — Fluvial (active): Fluvial deposits are materials that have been transported and deposited by streams and rivers. Active fluvial sediments in the map area are predominantly those associated with floodplains and channels of streams draining the Kluane Range. These deposits generally consist of stratified beds of gravel and/or sand with sand and/or silt and/or organic materials (and rarely clay). Gravels are typically rounded and contain interstitial sand. These deposits are commonly moderately to well-sorted and display stratification. Silt, sand, and organic deposits make up thinly laminated or massive overbank deposits that are rarely interbedded with coarser gravel deposits in active fluvial environments. Active fluvial channels migrate widely over alluvial fans in the southern part of the map area, reactivating previously abandoned channels and incising new channels. Permafrost is uncommon in active fluvial deposits.

FG — Glaciofluvial (inactive): Glaciofluvial deposits include materials that have been deposited by glacial meltwater either directly in front of, or in contact with, glacier ice (Howes and Kenk, 1997). Glaciofluvial materials typically range from non-sorted and non-bedded gravel made up of a wide range of particle sizes, associated with very rapid aggradation at an ice front, to moderately to well-sorted, stratified gravel. Slump structures such as hummocky or irregular terrain are indicative of collapse of the material due to melting of supporting ice. Glaciofluvial materials are present in the map area, but not abundant. Glaciofluvial materials are commonly interbedded and deposited adjacent to glacial diamict deposits at the ice front. They typically form kettled and hummocky plain surfaces, but are also present as ridged and undulating landforms when deposited along a glacier margin. Glaciofluvial deposits may be affected by permafrost but in most cases are ice-poor.

L — Lacustrine (inactive): Sediments that have settled from suspension and underwater gravity flows, such as turbidity currents, in bodies of standing fresh water, or sediments that have accumulated at their margins through the action of waves. Lacustrine materials in the map area are limited to deposits along the shore of Kluane Lake. Lakeshore lacustrine deposits are characterized by well-rounded and sorted gravel and sand with minor quantities of silt and rarely clay. Lakeshore lacustrine deposits are commonly affected by eolian processes and can be interbedded with eolian sand and silt deposits. Lacustrine beach deposits are rarely affected by permafrost.

M — Moraine (inactive): Moraine deposits include materials that have been deposited directly by a glacier or ice sheet without modification by any other agent of transportation. Moraine deposits are typically highly variable and depend upon both the source of material incorporated by the glacier and the mode of deposition (Howes and Kenk, 1997). Moraine deposits in the map area are characterized by poorly-sorted, weakly- to strongly-compacted material lacking stratification and containing a heterogeneous mixture of particle sizes, usually in a matrix of sand, silt and clay. Moraine deposits in the map area are typically found as ridged or flat-lying moraine blankets and plains. These moraine landforms are likely deposited at the base of a glacier, are strongly-compacted, and are more likely to be found close to the mountain front. The middle of the valley moraine is more likely to be mixed with glaciofluvial materials, have less silt and clay, and be weakly-compacted. It possible that basal moraine deposits similar to those found along the mountain front are buried at depth in the centre of the valley. Moraine deposits are commonly affected by permafrost and some moraine deposits may be ice-rich.

O — Organic (active): Organic materials in the map area are commonly found in low-lying areas where wet ground conditions have facilitated a thick accumulation of vegetative matter. Organic deposits contain at least 30% organic matter by weight, are commonly saturated with water and consist of the accumulated remains of mosses, sedges, or other hydrophytic vegetation (Howes and Kenk, 1997). In the map area, organic deposits form blankets (>1 m) and veneers (<1 m) over inorganic materials that commonly have poor drainage capacity due to a high percentage of silt and clay. In particular, the troughs found in ridged and rolling moraine deposits in the map area are prone to the accumulation of organic material because of the combination of poor drainage and impermeable surface materials. Ice-rich permafrost conditions are common in these deposits.

R — Bedrock: Bedrock outcrops in the map area are limited to higher elevation slopes along the mountain front of the Kluane Range. Bedrock is commonly sculpted by ice and overlain by thin deposits of glacial moraine and colluvial materials that thicken toward the valley bottom.

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, *etc.*). 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.

l - delta: landform created at the mouth of a river or stream where it flows into a body of water. Deltas have 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.

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.

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.

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 - 1 m in thickness; commonly applied to eolian/loess veneers and colluvial veneers.

w - mantle of variable thickness: a layer or discontinuous layer of surficial material of variable thickness (0-3 m) that fills or partly fills depressions in an irregular substrate.

x - thin veneer: a very thin layer of unconsolidated material; 2-20 cm thick.

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. Process is indicated by up to three upper case letters, listed in order of decreasing importance, placed after the surface expression symbol, and separated from the surface expression by a dash (-).

Subclasses can be 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 three subclasses can be attached to 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 channel zone is characterized by many diverging and converging channels separated by unvegetated bars. Many channels are dry at moderate and low flows, but during major floods, the entire channel zone may be occupied by flowing water

MASS MOVEMENT PROCESSES

F – slow mass movement: slow downslope movement of masses of cohesive or non-cohesive surficial material and/or bedrock by creeping, flowing or sliding.
Subclasses: (g) rock creep – slow movement of angular debris under periglacial conditions (*e.g.*, rock glaciers)

PERIGLACIAL PROCESSES

X - permafrost: processes controlled by the presence of permafrost, and permafrost aggradation or degradation
Z – general periglacial processes: solifluction, cryoturbation and nivation occurring together within a single terrain unit
Subclasses: (s) solifluction - slow gravitational downslope movement of saturated non-frozen overburden across a frozen or otherwise impermeable substrate

DEGLACIAL PROCESSES

E - channeled by meltwater: erosion and channel formation by meltwater alongside, beneath, or in front of a glacier or ice sheet
H - kettled: depressions in surficial materials resulting from the melting of buried glacier ice
T - ice contact: sediments deposited in contact with glacier ice

HYDROLOGIC PROCESSES

U – inundation: terrain seasonally under standing water which results from high water table

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 material. Up to three textural terms can be used to describe the texture of surficial material, where two or three symbols are used, they are listed in reverse order of importance so that the symbology may be easily verbalized.

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

Common clastic textural groupings:
d - mixed fragments
x - angular fragments
g - gravel
r - rubble
m - mud
y - shells

Organic terms:
o - organic: unclassified organic materials
e - fibric
u - mesic
h - humic

SYMBOLS

water courses
roads
elevation contours (feet a.s.l.)
moraine ridge
meltwater channel (direction indicated)
escarpment
esker (unknown direction)
strandline
fault or lineament (approximate)
fault or lineament (assumed)
site location (with station number)
gravel pit
kettle

Geological Boundaries
defined boundary
approximate boundary
assumed boundary
limit of geological mapping

ACKNOWLEDGEMENTS

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RECOMMENDED CITATION

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Digital cartography and drafting by Kristen Kennedy with the Yukon Geological Survey using ArcMap. Mapping based on digital air photo interpretation using 1:40 000-scale photos. Field checking was performed in summer 2012. Linework for map is based on aerial photography from 1985 through 1989 and may not match basedata (contours, streams) derived from 1:50 000-scale topographic maps.

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 2013-14

Surficial Geology of Burwash Landing and Destruction Bay (parts of NTS 115G/2, 6 and 7) Yukon (1:20 000-scale)

by
Kristen E. Kennedy

YUKON GEOLOGICAL SURVEY
Yukon Energy, Mines and Resources