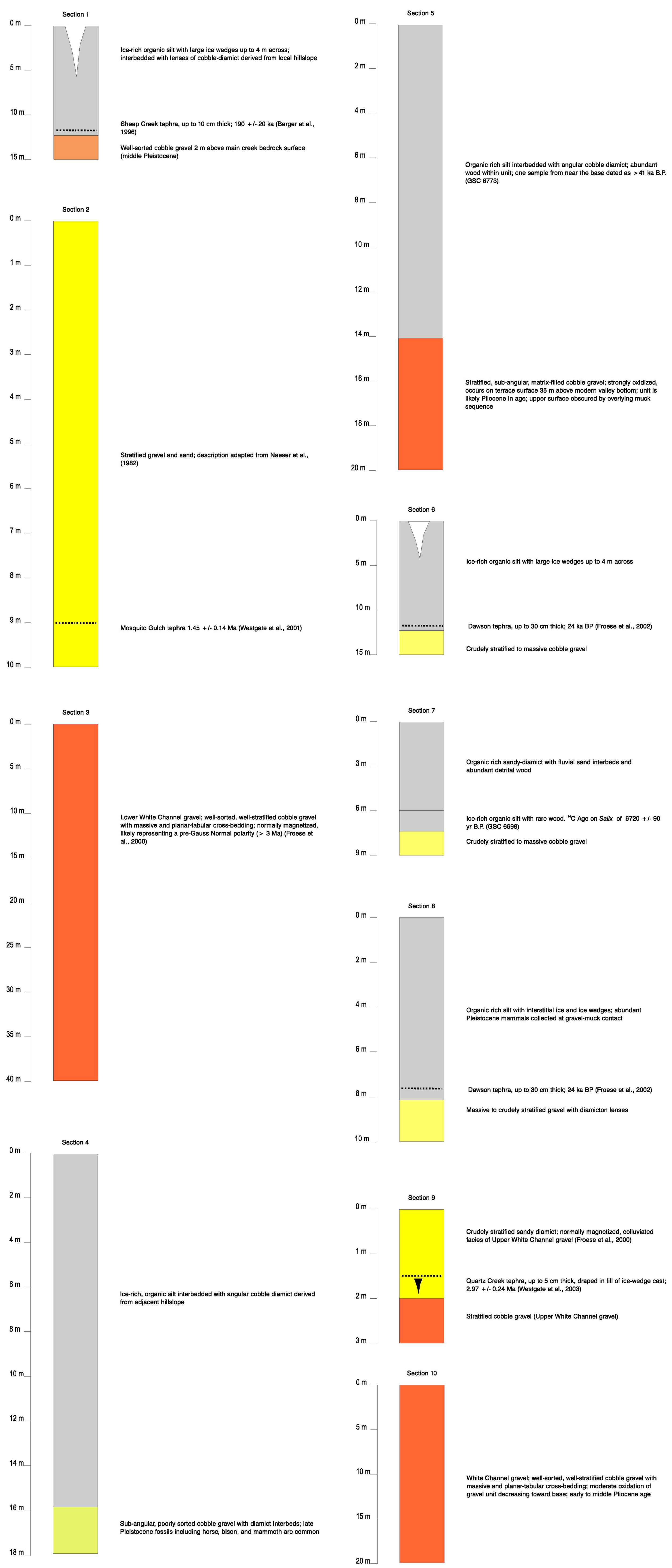


STRATIGRAPHIC LEGEND

Note: Not all stratigraphic units from the legend are present on stratigraphic logs

HOLOCENE (< 0.010 Ma)

- *Modern soil*
- *Stratified sand and gravel; alluvial sediments*

LATE PLEISTOCENE TO EARLY HOLOCENE (< 0.125 Ma)

- *Silt (organic rich), peat, and organic detritus, and extensive interstratified and segregated ice; collectively called muck*
- *Massive to stratified diamicton; colluvial sediments (may locally date to Middle Pleistocene)*
- *Massive to stratified silt and fine sand; eolian sediments*
- *Stratified silt and sand; resedimented eolian sediments locally interstratified with alluvial fan sediments*
- *Stratified sand and gravel; alluvial sediments*

MIDDLE PLEISTOCENE (0.780 - 0.125 Ma)

- *Paleosol developed in Reid and younger pre-Reid glaciofluvial sediments*
- *Stratified sand and gravel; glaciofluvial sediments deposited during Reid glaciation*
- *Stratified sand and gravel; glaciofluvial sediments deposited during younger pre-Reid glaciations (includes non glacial gravel in Last Chance Creek basin (section 1))*
- *Massive to stratified silt and fine sand; primary and resedimented eolian sediments*

LATE PLIOCENE AND EARLY PLEISTOCENE (2.7 - 0.780 Ma)

- *Paleosol developed in late Pliocene to early Pleistocene glaciofluvial and non-glacial sediments*
- *Stratified sand and gravel; glaciofluvial sediments deposited during older pre-Reid glaciations*
- *Stratified to massive diamicton; till deposited during one of several older pre-Reid glaciations*
- *Fine sand, silt and clay; lacustrine or slack water fluvial sediments*
- *Stratified to massive sand and gravel; non-glaciofluvial sediments, may be graded to pre-Reid outwash*

PLIOCENE (pre-glacial, 5 - 2.7 Ma)

- *Basalt and basalt breccia*
- *Stratified to massive gravel and sand; White Channel Gravel and equivalent clastic units predating regional glaciation, includes late Tertiary pediment sediments*

PRE-PLIOCENE (> 5 Ma)

- *Mesozoic and Paleozoic bedrock*

SYMBOL

- *Tephra - identification and age, if known, described on stratigraphic log*
- *Ice-wedge pseudomorph or sand wedge*
- *Ice-wedge*

DESCRIPTIVE NOTES

The Grand Forks map area lies within the unglaciated region of the Klondike Plateau, including the gold-bearing drainages of Bonanza Creek, Quartz Creek and part of Hunker Creek. The surficial geology consists largely of colluvial cover on the uplands and valley margins of varying thickness, with alluvium preserved on terraces and in valley bottoms with eolian and colluvial covers.

Early-to-mid Pliocene drainage of the area radiated from King Solomon Dome, the upland divide between the drainage basins of Bonanza-Hunker and Quartz-Sulfur-Dominion creeks. This pre-glacial drainage deposited the White Channel gravel (McConnell 1905, 1907) which is found on terraces cut into bedrock along the margins of Bonanza, Hunker and Quartz creeks. The strath (fluvially eroded bedrock) surfaces of these terraces that underlie the White Channel gravel are up to 100 m above the modern valley bottom on lower Bonanza and Hunker creeks, grading toward the modern valley bottom in the drainage headwaters.

The White Channel gravel is divided between the 'Lower' and 'Upper' White Channel gravel (Froese et al., 2000). Lower White Channel gravel is a characteristically light grey to white quartz-rich gravel. Its age ranges from earliest Pliocene at the base (ca. 5 Ma) to mid-Pliocene at its upper contact with the Upper White Channel gravel (ca. 3 Ma) (Froese et al., 2000; Westgate et al., 2003). At some sites, particularly along lower Hunker Creek, distinct alteration is visible in the Lower White Channel gravel, likely marking groundwater flow and diagenesis prior to the establishment of permafrost (Lowey, 2002). Lithologies of the White Channel gravel consist largely of white quartz and quartz-muscovite-chlorite schist, volcanic and meta-volcanic rocks derived entirely from the local drainage basin; paleoflow indicators similarly indicate a local source for the gravel and its associated gold. The Lower White Channel gravel aggraded in a braided-river environment with abundant proximal hillslope inputs from a heavily weathered regolith mantle (Morison and Hein, 1987). The Lower White Channel gravel is generally considered to have been deposited during the time in which the majority of gold was eroded from bedrock sources in the Klondike placer district.

Similar to the Lower White Channel gravel, the Upper White Channel gravel is derived entirely from local lithologies. Clasts are unleached and better preserved than those found in the Lower White Channel gravel, and show strong iron staining. Ice wedge casts, involutions (frost disruption of bedding) are common characteristics of the Upper White Channel gravel and indicate the first evidence of permafrost in the Klondike area. Section 9 on Quartz Creek preserves an ice wedge cast overlain by the Quartz Creek tephra, dated to 2.97 ± 0.24 Ma (Westgate et al., 2003), provides an approximate age for the Upper White Channel gravel. Distinction between the Lower and Upper White Channel gravel units is not always pronounced.

Terraces intermediate in elevation between the prominent Pliocene surfaces and low terraces (< 10 m) of the present valley bottom are rare. One noteworthy site on lower Bonanza Creek (section 2) at Archibald's Terrace occurs ~ 40 m above the valley floor and includes the early Pleistocene Mosquito Gulch tephra (1.45 ± 0.24 Ma) (Naeser et al., 1982; Sandhu et al., 2001; Westgate et al., 2001).

Valley bottoms of the Klondike Plateau, particularly at tributary junctions and north-facing slopes contain thick occurrences of primary and retransported loess and colluvium over local valley gravel (Map Unit: CEa), locally called 'muck' (Fraser and Burn, 1997; Kotler and Burn, 2000). These units tend to contain thick ground ice, including ice wedges that are highly unstable once disturbed. Most of these deposits aggraded during the late Pleistocene (< 30 ka), but older remnants dating to at least the middle Pleistocene are present marked by the Sheep Creek tephra (ca. 190 ka) (Berger et al., 1996) including section 2. The presence of middle Pleistocene tephra near the present valley bottom positions indicate that valley incision (as a proxy for uplift in the region) is low with rates of ~ 0.015-0.04 mm/yr based on tephras located within fluvial sequences on lower Bonanza and Hunker Creeks.

APPLIED SURFICIAL GEOLOGY

Placer exploration and development has occurred on most creeks in the Grand Forks map area following the initial discover of gold on Eldorado Creek in 1896. The valley bottoms of Bonanza-Eldorado, Hunker and Quartz have been highly disturbed by several generations of placer gold production. Modern permafrost is present and may be active on north-facing sites but is generally inactive or absent on well-drained south-facing sites. Once disturbed, permafrost may take a decade or more to stabilize through slumping and revegetation. Exploration geochemists should be aware that loess covers much of the valley bottoms and lower slopes of the map area. Its thickness is variable but it is thickest on north-facing sites. The loess is derived from local and distant sources. Consequently, the geochemistry of loess is a poor indicator of the geochemistry of the underlying bedrock.

REFERENCES

Berger, G. W., Pewe, T. L., Westgate, J. A., and Preece, S. J.
1996: Age of Sheep Creek Tephra (Pleistocene) in central Alaska from thermoluminescence dating of bracketing loess; Quaternary Research, v. 45, p. 263-270.

Fraser, T. A., and Burn, C. R.
1997: On the nature and origin of "muck" deposits in the Klondike area, Yukon Territory; Canadian Journal of Earth Sciences, v. 34, p. 1333-1344.

Froese, D. G.
1997: Sedimentology and paleomagnetism of Plio-Pleistocene lower Klondike valley terraces, Yukon; Unpublished M.Sc. thesis, University of Calgary.

Froese, D. G., Barendregt, R. W., Enkin, R. J., and Baker, J.
2000: Paleomagnetic evidence for multiple late Pliocene-early Pleistocene glaciations in the Klondike area, Yukon Territory; Canadian Journal of Earth Sciences, v. 37, p. 863-877.

Froese, D. G., Westgate, J. A., Preece, S. J., and Storer, J.
2002: Age and significance of the late Pleistocene Dawson tephra in eastern Beringia; Quaternary Science Reviews, v. 21, p. 2137-2142.

Kotler, E., and Burn, C. R.
2000: Cryostratigraphy of the Klondike "muck" deposits, west-central Yukon Territory; Canadian Journal of Earth Sciences, v. 37, p. 849-861.

Lowey, G. W.
2002: White Channel Gravel alteration revisited; *in* Yukon Exploration and Geology 2001, D. S. Emond, L. H. Weston, and L. L. Lewis (eds.); Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, p. 147-162.

McConnell, R.G.
1905: Report on the Klondike gold fields; *in* Annual Report for 1901, vol XIV, part B. Geological Survey of Canada, Publication No. 884, p. 1-71.

1907: Report on gold values in the Klondike high level gravels. Geological Survey of Canada, Publication No. 979.

Morison, S. R., and Hein, F. J.
1987: Sedimentology of the White Channel Gravels, Klondike area, Yukon Territory: fluvial deposits of a confined valley; *in* Recent Developments in Fluvial Sedimentology, F. G. Ethridge, R. M. Flores, and M. D. Harvey (eds.), Society of Economic Paleontologists and Mineralogists, p. 205-215.

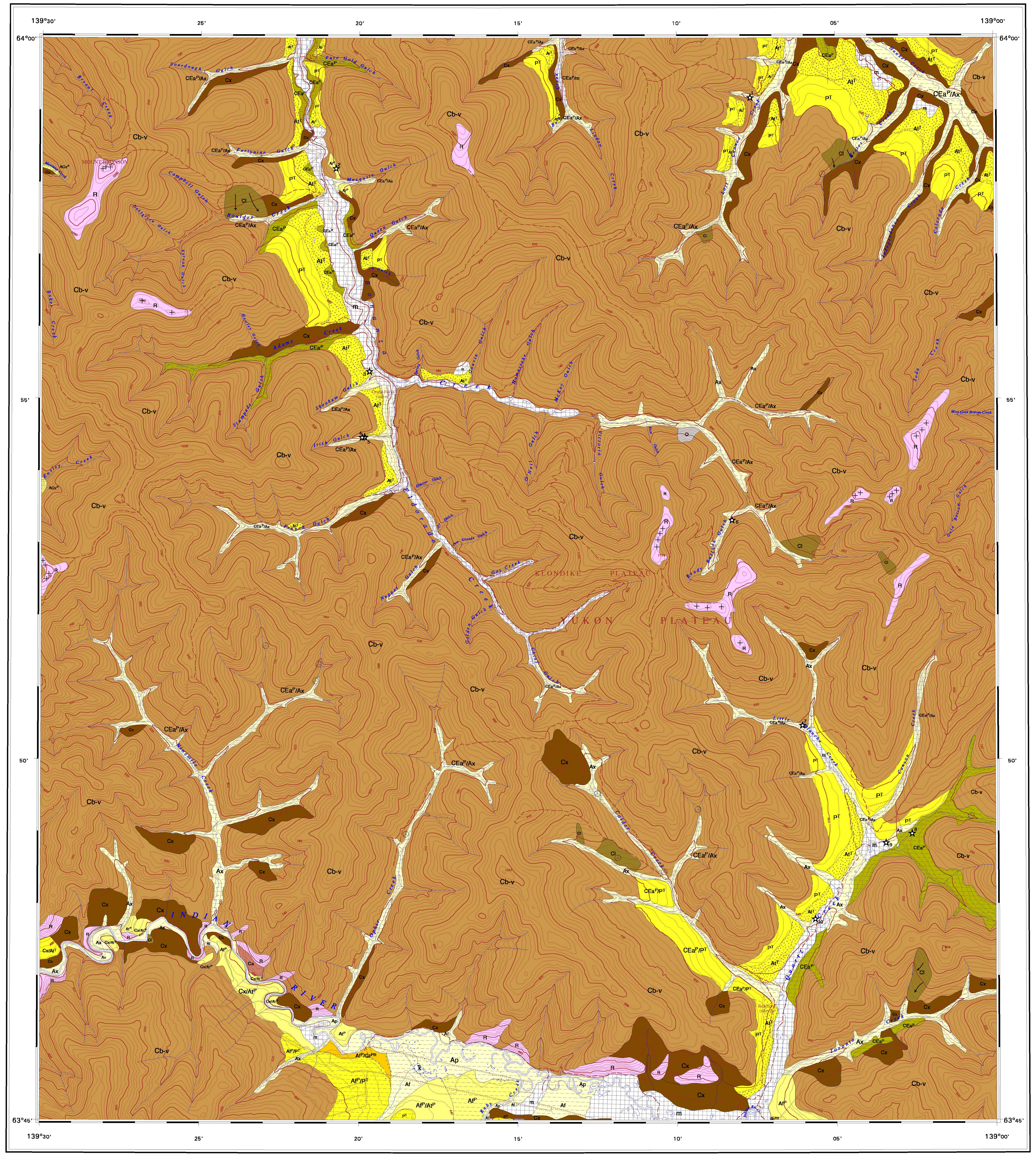
Naeser, N. D., Westgate, J. A., Hughes, O. L., and Pewe, T. L.
1982: Fission track ages of late Cenozoic distal tephra beds in the Yukon and Alaska; Canadian Journal of Earth Sciences, v. 19, p. 2167-2178.

Sandhu, A. S., Westgate, J. A., Preece, S. J., and Froese, D. G.
2001: Glass-fission-track ages of Late Cenozoic distal tephra beds in the Klondike district, Yukon Territory; *in* Yukon Exploration and Geology 2000, D. S. Emond, and L. H. Weston (eds.); Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, p. 247-256.

Westgate, J. A., Preece, S. J., Froese, D. G., Walter, R. C., Sandhu, A. S., and Schweger, C.E.
2001: Dating early and middle (Reid) Pleistocene glaciations in central Yukon by tephrochronology; Quaternary Research, v. 56, p. 335-348.

Westgate, J. A., Preece, S. J., Sandhu, A. S., and Froese, D. G.
2003: Age of the gold-bearing White Channel gravel, Klondike District, Yukon; *in* Yukon Exploration Geology 2002, D. S. Emond, and L. L. Lewis (eds.); Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada; p. 241-250.

Natural Resources Canada / Ressources naturelles Canada
GEOLOGICAL SURVEY OF CANADA / COMMISSION GÉOLOGIQUE DU CANADA
NATMAP / CARTNAT
Canada's National Geoscience Mapping Program
Le Programme national de cartographie géoscientifique du Canada



OPEN FILE 4591

SURFICIAL GEOLOGY

GRAND FORKS

YUKON TERRITORY

Scale 1:50 000/Échelle 1/50 000

kilometres 1 0 1 2 3 4 kilomètres

Universal Transverse Mercator Projection
North American Datum 1983

Projection transverse universelle de Mercator
Système de référence géodésique nord-américain, 1983

LEGEND

*Note: Map units listed below occur within one metre of the surface. Where organic or eolian sediments < 1 m thick overlie these, a pattern is overlaid upon the map unit. Along some valleys, colluvial or alluvial sediments > 1 m thick overlie older alluvial gravels that could contain placer gold. In order to accentuate these potentially exploitable deposits, a compound map unit is presented, e.g., **Cx/At^T**. This means that colluvial complex sediments overlie alluvial terrace sediments thought to be late Tertiary in age. This legend is part of a larger regional study hence coloured boxes indicate units that appear on this map. In addition, not all symbols in the legend are represented on this map.*

CENOZOIC

QUATERNARY

HOLOCENE

- m — ***Made Land:*** *placer mines, roads, and airstrip*

ORGANIC DEPOSITS: *peat and organic silt formed predominantly by the accumulation of vegetative material in bogs, fens, and swamps situated on valley bottoms; permafrost is commonly encountered within 1 m of the surface. Thermokarst collapse is common.*

- O — ***Organic Blanket:*** *undivided; thickness > 1 m to 5 m*
- ***Organic Veneer:*** *blanket bog generally < 1 m thick*

ALLUVIAL DEPOSITS: *gravel to silt size sediments, well stratified, deposited by streams*

- Ap — ***Floodplain Sediments:*** *gravel, cobble to pebble; massive to well stratified, capped by sand and silt; flat lying; includes lacustrine and organic deposits in abandoned channels and backswamp areas; subject to periodic inundation and reworking by floods; thickness 1 to 5 m*
- Af — ***Alluvial Fan Sediments:*** *gravel, sand, silt, and diamicton, massive to well stratified; sediments form fan-shaped landforms or complexes of coalesced fan-shape landform at the confluence of tributary streams; may be subject to flooding accompanied by sudden stream migration and inundation; thickness up to 10 m*
- Ax — ***Alluvial Sediments Complex:*** *sediments forming floodplains, fans, and terraces that cannot be subdivided at this map scale*

HOLOCENE AND PLEISTOCENE (UNDIVIDED)

COLLUVIAL DEPOSITS: *stony diamicton resulting from the physical and chemical breakdown of bedrock and subsequent reworking and transportation by creep, solifluction, and landsliding; colluvial deposits may contain reworked glaciofluvial and morainal sediments within the limits of pre-Reid ice-cover and reworked eolian sediments; colluvial deposits are products of formation and reworking over a significant part of the Pleistocene and Holocene epochs; surface is commonly hummocky or undulating*

- Cb-v — ***Colluvial Blanket and Veneer Sediments:*** *diamicton, stony with a sandy matrix; massive to poorly stratified; colluviated blankets generally conform to underlying bedrock and exceed 1 m in thickness; veneers are < 1 m in thickness and are commonly discontinuous over bedrock*
- Ca — ***Colluvial Apron Sediments:*** *bouldery diamicton and bouldery sandy gravel, poorly sorted; massive; sediments form a wedge-like slope-toe complex of small steep debris flow and solifluction deposits; thickness is < 1 m at the upper and lower slope limit to up to 5 m or more in the thickest part of the apron*
- Cl — ***Landslide Sediments:*** *silt loam to boulders, poorly sorted to unsorted; massive; clasts are subangular to angular and are locally derived; thickness varies greatly*
- Cx — ***Colluvial Complex Sediments:*** *areas of intergrading colluvial and alluvial sediments which are too complex to subdivide at the scale of mapping; unit may include colluvial and alluvial fan, colluvial blanket, landslide sediments and colluviated drift within the limits of glaciation; the unit commonly occurs along the lower slopes of valley margins*
- CEa^P — ***Colluvial/Eolian Apron (muck):*** *primary deposits of eolian fine sand and silt resedimented and interstratified with organic silt, and detritus, alluvial fan gravel and sand and variable amounts of stony colluvial diamicton; forms aprons along valley bottoms through resedimentation of eolian sediments from valley sides to valley floor, commonly preserved on north-facing slopes; thickness 1 to 20 m; commonly contains segregated bodies of ice and buried ice wedges*

MIDDLE TO LATE PLEISTOCENE (UNDIVIDED)

ALLUVIAL DEPOSITS: *gravel and sand deposited by streams that were not fed by glacial meltwater; sediments may have experienced several cycles of alluviation and erosion, but are now inactive due to burial or fluvial incision; basal gravels within these sediments commonly contain placer gold*

- At^P — ***Alluvial Terrace Sediments:*** *gravel, cobble to pebble with a sandy matrix; massive to well stratified; capped by sand and silt; sediments are of flood plain origin now isolated from flooding by stream incision; thickness 1 m to 10 m*
- Af^P — ***Alluvial Fan Sediments:*** *single fans or aprons of coalesced fans formed of gravel and sand, poorly to moderately sorted, now isolated from water and debris floods due to fluvial incision; sediments disturbed by cryoturbation; thickness up to 10 m*
- ACx^P — ***Alluvial/Colluvial Complex Sediments:*** *silt, sand and gravel, poorly to moderately sorted; thin to thick bedded, interstratified with colluvial diamicton; sediments underlie the floors and margins of narrow upland valleys and grade laterally up slope into colluvial blankets; sediments may represent several depositional cycles; thickness may exceed 10 m in mid-valley locations*

EOLIAN DEPOSITS: *well sorted medium sand to silt initially transported and deposited by wind action during glaciations and commonly resedimented through fluvial and colluvial processes; deposits of very fine sand and coarse silt < 1 m thick are distributed discontinuously throughout low lying areas*

- Eb^P — ***Eolian Blanket:*** *fine sand and silt, well sorted; massive; may form crescent-shape and linear dunes and featureless or gently undulating inter-dune eolian plains; thickness 1 to 5 m*
- ***Eolian Veneer:*** *thin deposits of very fine sand and coarse silt distributed discontinuously throughout low lying areas, thickness < 1 m*

LATE PLEISTOCENE - McCONNELL GLACIATION

GLACIOFLUVIAL DEPOSITS: *gravel and sand deposited by streams flowing away from glacial ice; deposits display poor soil development with rare cryoturbation*

- Gt^M — ***Glaciofluvial Terrace Sediments:*** *gravel and sand, unweathered, forming one or more terraces*

MIDDLE PLEISTOCENE - REID GLACIATION

GLACIOFLUVIAL DEPOSITS: *gravel and sand deposited by streams flowing away from glacial ice; deposits display moderate soil development with signs of cryoturbation; soil thickness < 0.5 m*

- Gt^R — ***Glaciofluvial Terrace Sediments:*** *gravel and sand, moderately weathered, forming one or more terraces*

LATE PLIOCENE TO MIDDLE PLEISTOCENE - pre-Reid GLACIATIONS (UNDIVIDED)

GLACIOLACUSTRINE DEPOSITS: *well stratified sand, silt, clay, deposited in lakes ponded by glacial ice*

- Lu^{PR} — ***Glaciolacustrine Undivided:*** *sand, silt, and clay; undifferentiated at this scale of mapping*

GLACIOFLUVIAL DEPOSITS: *gravel and sand deposited by streams flowing away from glacial ice in meltwater channels and outwash plains; massive to well stratified. Surface soils may extend to 2 m depth with well developed clay skins on clasts, frequent signs of cryoturbation (ice wedge pseudomorph and sand wedges), and strong chemical weathering*

- Gt^{PR} — ***Glaciofluvial Terrace Sediments:*** *gravel and sand, deeply weathered; incised into flights of terraces; thickness 1 to > 5 m*

MORAINAL DEPOSITS (TILL): *glacial diamicton, mainly till, generally consisting of a matrix ranging from sand to clay that supports clasts ranging from boulders to pebbles in size; deposited either directly from glacial ice or by gravity flow from glacial ice; surface soils may extend to 2 m depth with well developed clay skins on clasts, frequent signs of cryoturbation (ice wedge pseudomorph and sand wedges), and strong chemical weathering*

- Tb^{PR} — ***Till Blanket:*** *diamicton, stony, silty-sand matrix; massive; conforms to underlying topography, thickness > 1 m; extensively colluviated on slopes*
- Tv^{PR} — ***Till Veneer:*** *diamicton, stony, silty-sand matrix; massive; discontinuous and may contain extensive areas of thin (< 1 m) colluvium*

ALLUVIAL DEPOSITS: *Gravel and sand deposited by streams that were not fed by glacial meltwater; sediments may have experienced several cycles of alluviation and erosion, but are now inactive due to burial or fluvial incision; basal gravels within these sediments commonly contain placer gold*

- At^{PR} — ***Alluvial Terrace Sediments:*** *sandy pebble and cobble gravel deposited by streams having a fluvial source but graded to the margins of pre-Reid glaciers or glacial drainage; thickness 1 to 5 m*

UNDIFFERENTIATED DRIFT: *diamicton, gravel, sand, silt and clay deposited from glacial ice, glacial streams, and glacially damned lakes; extensive weathering, poor exposure and permafrost make differentiation into component glacial sediments difficult; thicknesses commonly exceed 10 m and mask underlying bedrock topography; commonly colluviated and intergraded with colluvium; surface soils may extend to 2 m depth with well developed clay skins on clasts, frequent signs of cryoturbation (ice wedge pseudomorph and sand wedges), and strong chemical weathering*

- D^{PR} — ***Drift:*** *flat to gently sloping*
- Dl^{PR} — ***Drift Modified by Landsliding:*** *drift translated along failure plains into irregular steps and sub parallel scarps*
- De^{PR} — ***Fluvially Incised Drift:*** *formerly extensive areas of drift incised by closely spaced stream valleys*

LATE PLIOCENE

- V^T — ***Basalt:*** *columnar alkaline olivine basalt and flow breccia; erosional remnants of formerly valley filling flows underlying terraces along lower Rosebud Creek; thickness 10 m*

PLIOCENE AND LATE MIOCENE

ALLUVIAL DEPOSITS: *preglacial gravel and sand; highly dissected and deeply weathered*

- P^T — ***Pediment and Bajada Sediments:*** *inclined fluvial surfaces which are found at a midslope position in unglaciated drainage systems; usually thinner than 5 m; formed as a result of limited agradation of stream gravel and significant colluviation; composed of thin, poorly sorted gravel that contains both locally derived subangular stream gravel deposits and angular bedrock fragments*
- At^T — ***High Level Terrace Sediments (includes White Channel Gravel and equivalent sediments):*** *weathered pebble to cobble gravel > 1 m thick; surface soils may extend to 2 m depth with well developed clay skins on clasts, frequent signs of cryoturbation (ice wedge pseudomorph and sand wedges), and strong chemical weathering; within the Yukon River valley, terraces above the 500 m contour may be remnant features from the southward-flowing paleo-Yukon River drainage system*

PALEOZOIC AND MESOZOIC

- R — ***Bedrock:*** *schist, gneiss, ultramafics, granodiorite, monzonite, marble, and basalt; includes areas of thin colluvial cover, blockfields, and sorted stone polygons in alpine areas*

SYMBOLS

- *Geologic contact; defined, approximate, inferred*
- *Open system pingo, collapsed open system pingo*
- *Thermokarst collapse activity*
- *Landslide movement direction in bedrock and colluvium*
- *Scarps created by widespread landslide movement in drift*
- *Terrace scarp (ticks on sloped side)*
- *Degraded Cirque: active during pre-Reid Glaciations*
- *Degraded Arête: active during pre-Reid Glaciations*
- *Meltwater channel: flow direction, unknown flow direction*
- *Large meltwater channel*
- *All time (pre-Reid) glacial limit; defined, inferred*
- *Cryoplanation terrace*
- *Tor*
- *Landform Streamlined by glacial ice*
- *Vertebrate fossil locality*
- *Stratigraphic section*
- *Fault trace*
- *Lineaments (fault, fracture, joint system) defined by linear drainage courses, aligned gaps in ridges, or aligned breaks in bedrock slopes*
- *Abandoned valley: paleoflow defined*
- *Abandoned valley: paleoflow undefined*
- *Paleoflow, suspected buried valley*
- *Rock glacier*

Geology by D.G. Froese and L.E. Jackson, Jr. (1999 - 2002)

Co-ordinated through the auspices of the Ancient Pacific Margin NATMAP

Digital cartography K. Shimamura, Terrain Sciences Division

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

Digital base map from data compiled by Geomatics Canada, modified by Parm Dhesi, Earth Sciences Sector Information Division (ESS Info)

Magnetic declination 2005, 25°48' E, decreasing 19.2' annually

Elevations in metres above mean sea level

Contour interval 20 metres

OPEN FILE
DOSSIER PUBLIC
4591
GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA
2005

Open files are products that have not gone through the GSC formal publication process.

Les dossiers publics sont des produits qui n'ont pas été soumis au processus officiel de publication de la CGC.

Recommended citation:
Froese, D.G. and Jackson, L.E., Jr.
2005: Surficial Geology, GRAND FORKS, Yukon Territory; Geological Survey of Canada, Open File 4591, scale 1:50 000.

Canada