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GEOLOGICAL SURVEY OF CANADA / COMMISSION GÉOLOGIQUE DU CANADA

NATMAP CARTNAT
Canada's National Geoscience Mapping Program
Le Programme national de cartographie géoscientifique du Canada

STRATIGRAPHIC SECTIONS

1

TM	Light grey-brown clayey-silt diamicton. Contains only montane lithologies. Clasts are entirely derived from the diamicton; these mark the maximum extent of continental ice in this region
PW	Diamicton. Clasts increase in size and abundance with depth. Contains only montane lithologies. A prominent reddish-orange paleosol is developed in the upper part of this unit; colour changes to orange-brown in the lower portion of this unit
GM	Strongly cemented, normally graded, coarse boulder to cobble gravel. All clasts have montane provenance
C	Covered by colluvium

2

L	Medium to dark brown soil developed in wind-blown silt (loess)
TC	Yellow-brown diamicton. Shield and montane provenance clasts (~10%) are sub angular to round
L	Interbedded clay, silt, and diamicton. Shield clasts are present. The depositional environment is interpreted as ice proximal lacustrine
C	Covered by colluvium
GM	Poorly sorted sand and gravel. No Shield clasts present. The finer fraction of matrix is derived from the Purcell Supergroup argillite; it coats clasts giving the section a pinkish colour
GM	Poorly sorted sand and gravel. No Shield clasts present. Finer fraction of matrix coats clasts to give a pinkish colour. This unit has a finer matrix and exhibits weak cementation in some areas
C	Covered by colluvium

3

GM	Stratified boulder to cobble gravel with a coarse sandy matrix; scattered silt and clay beds. The finer sediments (sands) exhibit ripples
TM	Reddish-brown silty-clay diamicton. Clasts are abundant (15-20%) and consist only of montane lithologies
L	Boulder pavement
L	Alternating beds of strongly deformed fine yellow sand and red pebbly mud
C	Covered by colluvium

4

E	Massive light greyish-brown very fine sandy eolian silt
TC	Upper Portion Light olive-brown silty-clay diamicton. Clasts (~10-15%) consist of both montane and Shield lithologies Lower Portion Medium yellow-brown diamicton. Clasts (5-10%) consist of both montane and Shield lithologies
TM	Greyish-pink silty-clay diamicton. Clasts are only of montane provenance
GM	Poorly sorted, sand, silt, and gravel. Composed only of montane lithologies
R	Bedrock

5

PW	Description from Karlstrom (1987); Barendregt et al. (1991); and Cioppa et al. (1996) at their trench 1 Paleosol/diamicton 5: Red to yellowish-red argillic unit (fossil Bt horizon). Calcium carbonate is absent from the upper part of the Bt. The lower part is calcareous and extremely weathered. Unit is significantly enriched in clay relative to the underlying parent unit. Upper 37 cm is a modern soil, pale brown. Soil has normal magnetic polarity
PW	Diamicton 5: Calcrete (fossil Bkm horizon) developed in a stony diamicton. Clasts are entirely derived from the Purcell Supergroup. Magnetic polarity is normal
PW	Paleosol/diamicton 4: Yellowish-red argillic (fossil Bt) horizon. It is significantly enriched in clay and iron relative to the underlying parent unit. 55-66% of clasts are extensively weathered. Magnetic polarity is uncertain but a reversed polarity is suspected
PW	Diamicton 4: Calcrete (fossil Bkm horizon) developed in a stony diamicton. Clasts are entirely derived from the Purcell Supergroup. Magnetic polarity is uncertain but a reversed polarity is suspected
PW	Paleosol/diamicton 3: Yellowish-red argillic (fossil Bt) horizons significantly enriched in clay and iron relative to the underlying parent unit. 55-66% of clasts are extensively weathered. Unit is magnetically reversed
PW	Diamicton 3: Calcrete (fossil Bkm horizon) developed in a stony diamicton. Clasts are entirely derived from the Purcell Supergroup. Magnetic polarity is reversed
PW	Diamicton 2: Calcrete (fossil Bkm horizon) developed in a stony diamicton. Clasts are entirely derived from the Purcell Supergroup. A paleosol separating diamictites 2 and 3 was observed in another exposure nearby. Magnetic polarity is uncertain
PW	Paleosol/diamicton 1: Argillic (fossil Bt) and calcrete (Bkm) horizons. Yellowish-red colour range. Enriched in clay and iron relative to the underlying parent unit. Magnetic polarity is normal
PW	Diamicton 1: Calcrete (fossil Bk horizon) developed in a stony diamicton. Clasts are entirely derived from the Purcell Supergroup. Unit is seen to overlie bedrock nearby. Magnetic polarity is uncertain

Vertical scale (metres)
5
0

REFERENCES

Barendregt, R.W., Irving, E., and Karlstrom, E.T.
1991: Paleomagnetism of Quaternary and late Tertiary sediments on Mokowan Butte, southwestern Alberta; Canadian Journal of Earth Sciences, v. 28, p. 1956-1964

Cioppa, M.T., Karlstrom, E.T., Irving, E., and Barendregt, R.W.
1996: Paleomagnetism of tills and associated paleosols in southwestern Montana: evidence of late Pliocene and early Pleistocene glaciations; Canadian Journal of Earth Sciences, v. 32, p. 555-564

Karlstrom, E.T.
1987: Stratigraphy and genesis of five superimposed paleosols in pre-Wisconsinan drift on Modowan Butte, southwestern Alberta; Canadian Journal of Earth Sciences, v. 24, p. 2235-2253

SUBSURFACE UNITS

Postglacial

O	Peat
C	Colluvium
E	Eolian fine sand and silt
A	Alluvial sand and gravel
L	Lacustrine sand, silt, and clay

Wisconsinan -- Erratics Train Glaciation

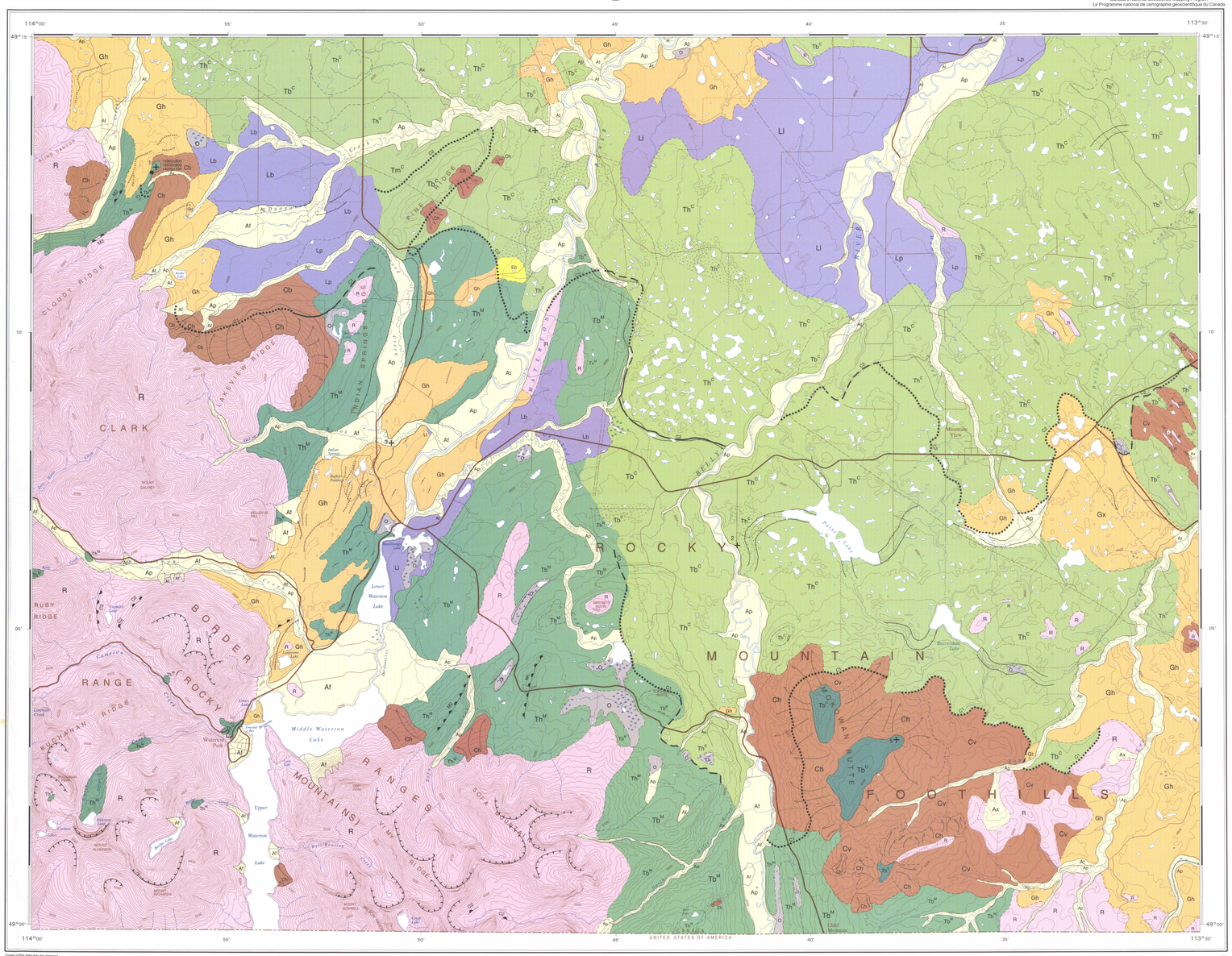
LE	Laminated and thinly bedded glaciolacustrine sand, silt, and clay
GC	Outwash gravel and sand containing clasts from Canadian Shield
GM	Outwash gravel and sand (Rocky Mountains and Foothills provenance)
TC	Till and related glaciogenic diamictons containing clasts transported from the Canadian Shield
TM	Till and related glaciogenic diamictons of Rocky Mountains and Foothills provenance

Pre-Wisconsinan

PW	Rocky Mountains provenance glacial sediments and interstratified paleosols

Preglacial

R	Sandstone and shale



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LOCATION MAP

Geology by E.C. Little, 1994

Co-ordinated by D. Lebel through the auspices of the Southeastern Cordillera NATMAP Project

Digital cartography by K. Shimamura, Terrain Sciences Division and E. Everett, Geoscience Information Division

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

MAP 1935A

SURFICIAL GEOLOGY

WATERTON LAKES

ALBERTA

Scale 1:50 000 - Échelle 1/50 000

Kilometres 1 0 1 2 3 4 Kilometres

Universal Transverse Mercator Projection
Projection transverse universelle de Mercator

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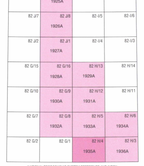
Digital base map from data compiled by Geomatics Canada, modified by the Geoscience Information Division

Copies of the topographic map for this area may be obtained from the Canada Map Office, Natural Resources Canada, Ottawa, Ontario K1A 0E9

Some geographical names subject to revision

Magnetic declination 1998, 17°11'E, decreasing 6.1' annually

Elevations in feet above mean sea level



Published 1998

LEGEND

Not all coloured units and symbols in legend necessarily appear on this map
This legend is common to maps 1925A to 1936A

QUATERNARY

HOLOCENE - Post Erratics Train Glaciation

m	***MADE LAND:*** *Artificial fill and mine waste*
I	***EXISTING GLACIERS, ICE:*** *Flowing or stagnant glacial ice; contains or is covered by variable amounts of rock debris ranging from clay to boulders; thickness of ice 20 - 40 m*
O	***ORGANIC SEDIMENTS:*** *Water-saturated* **Sphagnum** *peat and organic silt formed predominantly by the accumulation of vegetal material in bogs, fens, and swamps; organic deposits are usually underlain by lacustrine silt and clay; thickness up to 5 m*
Eb	***EOLIAN SEDIMENTS:*** *Sand and silt transported by wind* ***Eolian blanket:*** *Sand, well sorted, massive; forms gently undulating plains marked by crescent-shaped dunes; thickness up to 5 m*
Cb	***COLLUVIAL SEDIMENTS:*** *Stony diamicton resulting from the mixture of varying amounts of broken bedrock, soil, and glacial sediments by nonfluvial gravitational processes such as creep, solifluction, rockfall, and mass wasting; some of the material in colluvial glacial sediments in colluvium occur within the limits of past glaciations* ***Colluvial blanket sediments:*** *Diamicton, stony, massive, 1 to 2 m thick*
Cv	***Colluvial veneer sediments:*** *Diamicton, stony, massive, <1 m thick or patchy; overlies bedrock*
Ca	***Colluvial apron sediments:*** *Bouldery diamicton and poorly sorted and stratified sand and gravel; sediment is in a wedge-shaped slope-toe surface of small steep debris fans and extensive coalescent fans and colluvial blankets; diamicton and sand and gravel are in close proximity; thickness ranges from <1 m at the up slope limit to up to 10 m in the thickest part of the apron*
Cc	***Rockfall sediments:*** *Bouldery rockfall deposits; forms cone-shaped landforms at the angle of repose below steep bedrock slopes; thickness ranges from <1 m at the margin to 10 m near the midpoint of the cone*
Ch	***Landslide sediments:*** *Diamicton formed of broken rock, soil, and glacial deposits; forms a hummocky or ridged topography with ridges transverse to direction of movement; thickness variable, may range up to 10 m (direction of movement indicated by symbol)*
Cx	***Undivided colluvial sediments:*** *Hummocky apron terrain adjacent to mountainous uplands, possibly of mass wasting origin*
Ap	***ALLUVIAL SEDIMENTS:*** *Gravel to silt size sediments deposited by streams either within channels or as overbank deposits. Deposits are commonly stratified and moderately to well sorted, with the exception of some alluvial fan deposits* ***Alluvial plain sediments:*** *Gravel and sand, massive to stratified, moderately to well sorted; locally overlain by or includes lacustrine silt and clay and minor peat and organic silt deposited in abandoned channels and along floodplain margins; forms plains within about 1 m of present stream level which are subject to inundation during floods; thickness 1 to 5 m*
At	***Alluvial terrace sediments:*** *Gravel and sand, massive to stratified, moderately to well sorted; sediments are of floodplain origin now isolated from flooding by stream incision; thickness ranges from a discontinuous covering on bedrock to several metres; where alluvial terraces are cut into glaciofluvial plains, total thicknesses of gravel and sand may be 5 m or more*
Af	***Alluvial fan sediments:*** *Gravel and gravelly diamicton, stratified, poorly to moderately sorted; forms fan-shaped landforms where streams enter larger valleys; in mountainous terrain, alluvial fans may be subject to inundation or debris flows; thickness up to 10 m*
Ax	***Alluvial complex sediments:*** *Floodplains, fans, and terraces that cannot be subdivided at the scale of mapping*

WISCONSINAN - Erratics Train Glaciation
Sediments deposited during advances and retreats of glaciers from Rocky Mountains and continental interior

Lv	***GLACIOLACUSTRINE DEPOSITS:*** *Well stratified sand, silt, and clay deposited in lakes dammed by glacial ice. Where deposition was distant from ice margins, glaciolacustrine sediments underlie plains or gently rolling terrain; where deposition was near ice, they may underlie rolling hummocky or pitted terrain caused by subsequent ice melting; May include some proglacial lacustrine sediments* ***Glaciolacustrine veneer sediments:*** *Silt, clay, and fine sand; well stratified, thinly bedded to laminated or discontinuous; thickness <1 m thick to discontinuous*
Lb	***Glaciolacustrine blanket sediments:*** *Silt, clay, and fine sand; surface morphology conforms to underlying topography*
Ll	***Glaciolacustrine plain sediments, local relief <1 m:*** *Silt, clay, and fine sand; thinly bedded to laminated; surface morphology is a plain and underlying topography is generally obscured by these sediments; thickness 1 to 20 m*
Lp	***Rolling glaciolacustrine plain sediments, local relief 1-2 m:*** *Fine sand, silt, and clay, thinly to massively bedded; surface morphology undulating; underlying topography is generally obscured by these sediments; thickness 1 to 20 m*
Lh	***Ice-contact glaciolacustrine complex sediments:*** *Predominantly silt and sand; gravel, diamicton lenses and dropstones may comprise up to 10% or more of this unit; bedding thin to massive; bedding is commonly deformed due to syndepositional slumping and ice melting; surface morphology is hummocky, pitted, and ridged with relief up to 10 m; commonly underlain by hummocky moraine sediments; thickness 5 to 10 m*
	GLACIOFLUVIAL SEDIMENTS: *Sand, gravel, and minor silt and diamicton deposited by streams flowing away from, or in contact with glacial ice. Sorting ranges from good to poor and stratification from thinly bedded to massive. Sediments may display evidence of syndepositional collapse due to melting of buried or supporting ice. In areas formerly covered by glaciers from the Rocky Mountains only, lithologies include Precambrian and Paleozoic limestone, dolostone, argillite, and quartzite, and may include mafic and felsic volcanic rocks in the Dillman River basin. In areas covered by montane glaciers and glacier ice from the continental interior, lithologies include Paleozoic limestone, dolostone, sedimentary and Canadian Shield provenance granitic and metamorphic lithologies*
Gp	***Glaciofluvial plain and fan sediments:*** *Gravel and sand, massive to thickly bedded; former outwash plains and fans; thickness 1 to 10 m*
Gt	***Terraced glaciofluvial sediments:*** *Gravel and sand, massive to thick bedded; former outwash plains and fans incised into a succession of terraces; thickness 1 to 10 m*
Gd	***Glaciofluvial delta sediments:*** *Sand, gravel, and minor silt and clay; thinly bedded to massive; flat surfaced, delta form in plan view; deposited as a delta along the margin of a former glacial lake; thickness from 3 to 10 m*
Gh	***Glaciofluvial ice stagnation complex sediments:*** *Sand, gravel, diamicton, and minor silt and clay; thinly bedded to massive; sediments are commonly deformed due to melting of buried or supporting ice melting; surface morphology includes hummocks, kettle, esker and crevasse-fill ridges 2 to 10 m in relief with minor elements of unit Gp and Gt; thickness 5 to 10 m*
Gx	***Undivided glaciofluvial and ground moraine sediments:*** *A patchwork of glaciofluvial sediments and ground moraine (till) too variable to resolve at the scale of mapping*
Gv	***Glaciofluvial veneer sediments:*** *Gravel and sand, massive to thickly bedded; thickness <1 m or patchy; overlies bedrock*
	MORAINAL SEDIMENTS (till): *Diamicton (pebble to boulder size clasts suspended in a poorly sorted clay to sand size matrix) deposited directly by glacial ice, redeposition, where it has occurred, has been minimal; unless noted, lithologies include Precambrian and Paleozoic provenances were deposited during the Erratics Train Glaciation; Tv contains clasts of Rocky Front and Main ranges Precambrian and Paleozoic limestone, dolostone, and quartzite; Foothills and Interior Plains Mesozoic and lower Tertiary sandstone, mudstone, and coal, as well as Canadian Shield provenance granitic and metamorphic rocks. Tr contains Rocky Mountain Precambrian and Paleozoic limestone, dolostone, and quartzite; Foothills and Interior Plains Mesozoic and lower Tertiary clasts of Crowsnest Fm(n); and Foothills Mesozoic and lower Tertiary sandstone, shale, and coal (includes lower Cretaceous volcanics in the Crowsnest Pass area). Trace amounts of Canadian Shield provenance clasts are present only where montane ice overran pre-existing drift containing Canadian Shield provenance clasts* ***Till veneer:*** *<1 m thick or discontinuous diamicton with patches of exposed bedrock or colluvium. Tv generally contains more and coarser pebble and larger clasts than Tv and both may contain extensive areas of thin (<1 m) and patchy colluvium; overlies bedrock*
Tv Tr	***Till blanket:*** *1 to 5 m of diamicton that conforms to the underlying bedrock topography. Tb generally contains more and coarser pebble and larger clasts than Tb*
Tb Tb	***Hummocky moraine:*** *Diamicton and interstratified glaciofluvial gravel and sand; massive to thickly bedded; poorly sorted, faulted, and folded by syndepositional melting; surface morphology is hummocky with kettle lake fine sand and silt; forms hummocky, kame and kettle topography; local relief up to 30 m; thickness may be tens of metres*
Th Th	***Rolling till plain:*** *More than 5 m of diamicton; surface morphology undulates with 1-2 m local relief; totally or largely obscure surface morphology of underlying bedrock*
Tm Tm	**EARLY PLEISTOCENE OR PLIOCENE GLACIAL OR NONGLACIAL SEDIMENTS**
Tb	***TRT blanket:*** *Stony diamicton cemented to a calcrete; contains striated clasts; thickness 2 to 3 m; rests on a succession of similar sediments of glacial or nonglacial origin*

PALEOZOIC TO EARLY TERTIARY ROCK

R	*Sandstone, siltstone, shale, mudstone, conglomerate, coal, and minor volcanic rocks of early Tertiary and Mesozoic age and limestone, dolostone, and quartzite of Paleozoic and Precambrian age (includes areas of thin colluvial cover, blockfields, sorted stone polygons in alpine areas)*
R-A	*Areas of rock as above subject to rapid mass wasting processes (rockfall and snow avalanches)*
R-G	*Upper Mesozoic and Early Tertiary rock eroded into badland topography*

VENEER

	Glaciolacustrine
	Eolian
	Organic

Geological boundary (defined, assumed, inferred)

Neoglacial lateral or end moraine

Arête

Cirque

Meltwater channel:
large
small (flow direction known, unknown)

edge of ice-walled channel

Esker (flow direction defined, undefined)

Landform streamlined by glacial ice (direction of flow known, unknown)

Ice limit (defined, assumed, inferred):
M1 *Maximum ice limit of Late Wisconsinan montane glacial ice*
M2 *Ice limit one of first major readvance of Late Wisconsinan montane glacial ice*
C1 *Readvance position of Late Wisconsinan continental glacial ice*
C2 *Readvance position of Late Wisconsinan continental glacial ice*

Lateral and end moraine (associated with advance M1, M2, or retreat of continental ice sheet from limit C2)

Former ice contact face in stratified drift

Stratigraphic section

Vertebrate fossil locality

Radiocarbon age (years before present) 10060±100 GSC 2182

One or more Foothills Erratics Train Erratic >1 m in length

*Cosmogenic ^{36}Cl exposure age on Foothills erratic (years before present)** 15000±400

Montane erratic close to or at the all time upper limit of montane glaciation

Canadian Shield erratic at or near the all time upper limit of continental glaciation

*Cosmogenic ^{36}Cl exposure age of Canadian Shield erratic at or near the all time upper limit of continental glaciation (years before present)** 22500±1200

Arrows indicating direction of landslide movement (associated with unit Ch)

** Assumes a zero erosion rate and no cosmic ray blockage by snow cover*

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1998: Surficial geology, Waterton Lakes, Alberta; Geological Survey of Canada, Map 1935A, scale 1:50 000

1935A

Canada

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