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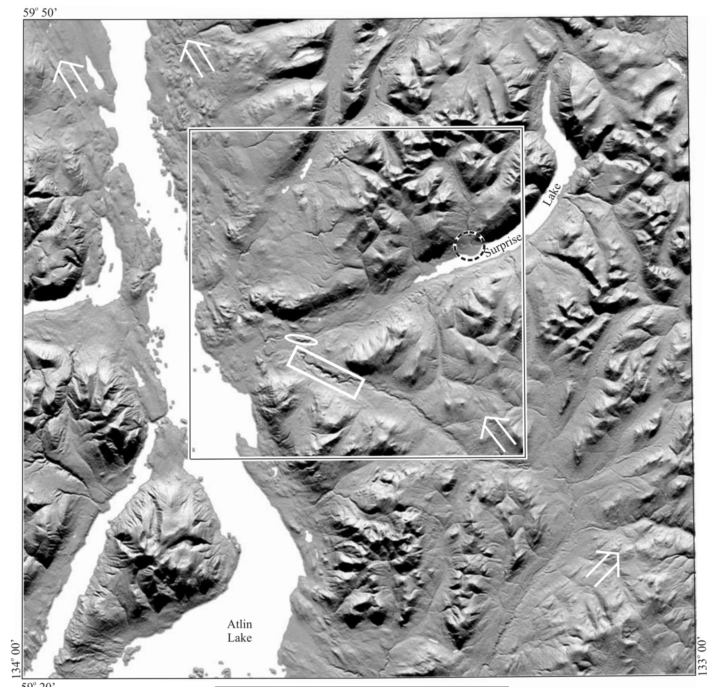
INTRODUCTION

This surficial geology and placer potential map of the Atlin area was originally produced by the British Columbia Geological Survey (Levson and Kerr, 1992) following a 1991 field program investigating the geology of placer gold deposits in the Atlin mining district (Levson, 1992). This map is an updated colour version of the map presented by Levson and Kerr (1992) and includes results of new work conducted under the Atlin Targeted Geoscience Initiative by the British Columbia Geological Survey Branch and the Geological Survey of Canada. New data includes recently published research on the Quaternary geology of the area (Levson and Blyth, 2001), new field observations and geochemical data on platinum in placer deposits (Levson *et al.,* 2002), and a digital elevation model of the region produced by Lowe *et al.* (2001; Figure 1). Map units have been revised to include the chrono-stratigraphic designations as well as surficial materials information but unit boundaries have not been altered.



LEGEND

alluvial fan delta
ice flow direction
anthropogenic activity
Esker

Figure 1: *Digital elevation model for a portion of the Atlin map area (from Lowe et al., 2001). Black polygon denotes the extent of the 1:50 000 map. See Lowe et al. (2001) for a detailed description of the surficial and anthropogenic features identified.*

SURFICIAL GEOLOGY

Steep mountainous areas are characterized by bedrock exposures (**R**) and a thin colluvial veneer (**Cv**). More gentle slopes at high elevations may have a blanket (**Cb**) of glacially derived diamicton, resedimented by slope processes after deposition. Many high-elevation areas are subject to rapid mass movements (rock falls and debris flows) and slow avalanches. Rock glaciers, solifluction lobes and stone stripes are common at high-elevation. Landslide debris typically consists of angular bedrock material ranging in size from sand to large boulders and some surficial sediments. Periglacial features such as solifluction lobes, stone stripes, nivation hollows and cryoturbated soils are common, especially in the northwest part of the map area and to a lesser extent along the high mountains in the south. Talus deposits are common below most bedrock cliffs and rock glaciers occur in some high cirques.

Lower slopes and valley bottoms are typically covered by morainal deposits (**M**) consisting of unsorted, massive diamicton. These deposits are generally matrix-supported with clasts up to boulder size occurring in a mixture of sand, silt and clay. They are typically compact, impermeable and poorly drained. On slopes, these deposits are often overlain by 1-2 metres of poorly consolidated, sandy diamicton produced by colluvial processes (**Cv**). Colluvium consists of reworked glacial debris mixed with angular local materials and are commonly interbedded with thin lenses of sorted gravel, sand and silt.

Glaciofluvial sands and gravels ($\mathbf{F^G}$) are most concentrated along the valley bottoms of Spruce, Pine, Otter and Fourth of July creeks. Glaciofluvial deposits consist mainly of well-sorted, well-stratified, non-cohesive gravels and sands. They typically have a high porosity and permeability and are well drained. Clasts are generally well-rounded and in the pebble to cobble size range. Well-developed terraces occur in the lower Spruce Creek and Pine Creek valleys and merge with raised glaciofluvial delta complexes east and northeast of Atlin. The southermost part of a large kettled delta complex occurs in the Fourth of July Creek valley at the northern edge of the map area. An ice contact kame complex occurs at the mouth of Otter Creek and there are esker complexes in the lower reaches of Spruce Creek.

Glaciolacustrine sediments ($\mathbf{L^G}$) are uncommon surficial deposits in the map area but occur along the shore of Atlin Lake and along Fourth of July Creek. They form a thin, discontinuous veneer over morainal materials and bedrock and are typically comprised of cohesive, impermeable, laminated to massive, silts and clays. Sandy to pebbly, raised, beach deposits occur along Atlin Lake (Lacelle, 1985).

Fluvial deposits are confined mainly to alluvial fans (**Ff**) at the mouths of creeks entering the Surprise Lake valley, the Pine Creek fan-delta at Atlin Lake and narrow floodplains and terraces (Ft) throughout the area (e.g. Pine Creek). They are similar to glaciofluvial deposits but tend to be finer grained and often water saturated. Fluvial sediments occur at elevations close to stream level compared to glaciofluvial sediments. Bog and marsh deposits (**O**) occur mainly in valley bottoms, particularly along Atlin Lake, over poorly drained substrate.

More detailed descriptions of map units in the Atlin area can be found in a report on terrain capability for residential settlements (Lacelle, 1985) and in a paper on the Quaternary geology of the Atlin area (Levson, 1992).

Figure 2: *Basalt colums overlying late Tertiary to early Pleistocene auriferous gravels in Ruby Creek. Photograph by V. Levson, 2001.*

QUATERNARY HISTORY AND CHRONOLOGY

Glaciation in the Atlin area was preceded by an extensive period of preglacial fluvial valley incision during which many of the placer deposits in the area accumulated. These paleoplacers are stratigraphically overlain by peat and wood that underlies till of one or more glaciations. The organics yield non-finite radiocarbon dates and indicate that placer deposition occurred prior to 31 ka at Boulder Creek and before 36 ka at McKee Creek (Levson, 1992). At Ruby Creek, the gold-bearing gravels are overlain by basalts (Figure 2) yielding potassium-argon dates ranging from 0.5 to 3.6 Ma, indicating a Late Tertiary to Early Pleistocene age for the gravels (Levson and Blyth, 1993).

During the last glaciation, ice initially moved into the Atlin region down major valleys from accumulation centres in the Coast Range. Ice occupied the Atlin Lake valley before the smaller tributary valleys, resulting in damming of streams such as Spruce Creek and McKee Creek, just south of the map area. The Boulder and Otter Creek drainages were also dammed, possibly by Atlin valley ice moving into the Pine Creek - Surprise Lake valley. Prograding glaciofluvial delta complexes (Figure 3) with steep-dipping sand and gravel foreset beds formed in the lower reaches of all these creeks where they flowed into the ice-dammed lakes. During full glacial times, the region was almost entirely ice covered by a generally north-flowing ice sheet that left an ubiquitous surficial cover of glaciogenic sediments. Well-developed moraines are rare, but recessional moraines occur in a few places such as in the upper Ruby Creek valley.

During deglaciation, ice-contact kame and esker complexes formed in a number of areas and a glacial lake system developed locally in the Atlin Lake valley. Meltwater streams from Pine and Spruce creeks deposited glaciofluvial deltas northeast and east of Atlin. As the lake level dropped, deltas and correlative beaches and outwash terraces were constructed at successively lower levels. The highest lake level in the area, determined by the distribution of glaciolacustrine sediments and by maximum delta elevations, was at about 780 metres above sea level. A glacial lake also formed in the McDonald lakes area as a result of damming by Atlin valley ice retreating down the Fourth of July Creek valley (Tallman, 1975). The elevation of large pitted deltas along Fourth of July Creek northeast of McDonald Lakes indicates that the maximum glacial lake level there was higher than 1000 metres above sea level.

During and following deglaciation, previously deposited glacigenic sediments were extensively reworked by colluvial processes under paraglacial conditions. These resedimented deposits are common at the base of steep slopes. Similarly, paraglacial alluvial-fan sedimentation was probably very active during deglaciation and has continued, at slower rates, to the present. Wood buried less than 1 metre from the surface on the Boulder Creek fan, yielded a radiocarbon date of 2270 ± 90 years B.P. (AECV-1500C) indicating that fan sedimentation has been slow for at least the last two millennia. At high elevations, periglacial processes have played a large role in the evolution of geomorphic features throughout much of the Holocene. At least one major postglacial landslide has occurred in the area, extending from the east side of Ruby Mountain across the Ruby Creek valley (Levson, 1992). Fluvial terrace, floodplain and active channel deposits have also formed along valley bottoms during the Holocene.

Figure 3: *Steeply-dipping sand and gravel foreset beds in a prograding glacioflucial delta complex, Boulder Creek. Photograph by V. Levson, 2001.*

PLACER POTENTIAL

Potential buried-channel deposits

Spruce Creek has produced more placer gold than any other stream in British Columbia and buried fluvial channel deposits in the valley continue to support mining operations. Most activity has been concentrated along the lower end of the creek. Much of the valley upstream of the Nolan underground mine, near the confluence of Spruce and Dominion creeks, has good potential. Depth of ice-erosion and thick glacial and fluvioglacial overburden are the main factors limiting the location and exploitation of these deposits. The extent of historical underground mining is generally not accurately known and as a result it is difficult to determine the total volume of auriferous gravels remaining.

Pine Creek is the second largest placer producing stream in British Columbia and it is probable that any undiscovered paleochannels of Pine Creek, downstream of Surprise Lake, would also be highly auriferous. Although thick glacial and glaciofluvial overburden inhibits exploration, there may be potential for expansion of mining operations upstream and downstream of previously mined areas. On the north side of the valley, broad, linear topographic lows are recognizable on airphotos and may represent surface expressions of former gold-bearing paleochannels. The most prominent linear depression, paralleling Pine Creek, is in part occupied by Moose and Elk lakes. Similarly, the area between the Birch Creek confluence and Surprise Lake has not been mined and, given the historical productivity of upstream tributaries such as Otter, Boulder and Ruby creeks, it seems probable that paleochannels in that area could also be gold bearing. Data on the depth of ice erosion and consequent placer preservation potential in these areas has not been evaluated.

Confined channel gravels below Pleistocene basalts and rock avalanche deposits in the Ruby Mountain area were identified as having good placer potential by Levson (1992) and these deposits continue to be mined today (Figure 2). Unexploited paleochannel deposits, on Ruby Creek and on others such as, Boulder and Birch creeks, will mostly be small channel remnants on the valley sides, but there is local potential for more extensive deposits in areas where the valley widens. In addition, there is buried placer potential on lower Otter and Wright creeks in low lying areas south of Surprise Lake. The stratigraphy of the productive Otter Creek paleoplacer was described by Levson and Blyth (1993) and, on the basis of similar geomorphic and geological characteristics, the Wright Creek valley was identified as also having high potential for a large, buried channel placer deposit (Levson, 1992). This interpretation was confirmed in recent years by a large, deep, open-pit mine exploiting buried placer deposits along Wright Creek (Levson and Blyth, 2001).

There is potential for buried alluvial-fan channel deposits at the mouths of most of the historically productive creeks in the area, particularly Otter, Birch, Boulder, McKee and Ruby creeks. The most productive parts of the channels would occur on bedrock near the paleofan apex. The continuity of the channels in the lower parts of the fans may have been disrupted by glacial erosion and the depth of burial there would also be greater than near the fan apex.

Potential Holocene placers

Postglacial placers are generally less productive than buried channel deposits except in areas where the younger streams have reworked older placer deposits. In other areas, the lower grade Holocene stream deposits can still mined when efficient mining operations with good recovery systems are employed. Holocene alluvial fan placer deposits have not been heavily exploited to date in the region, mainly because they are relatively low grade and typically contain finer gold than buried-channel deposits. Large-volume surface placers include alluvial-fan deposits at the mouths of Boulder, Ruby and Birch creeks and to a lesser extent fan deposits on lower Otter and Wright creeks. The most productive parts of the alluvial fan deposits are expected to be coarse-gravel facies near the fan-head channels.

Holocene fluvial deposits have been mined on some creeks in the area particularly in deeply incised valleys, such as Birch, Boulder, Otter, Ruby, lower Spruce, Snake and upper Wright creeks, where gold has been reconcentrated from older gravel units. Near-surface fluvial placers in the upper parts of these streams may be locally productive but these deposits are generally thin. Low terraces along Spruce and Pine creeks contain some fine gold and locally, are mineable. These gravelly deposits are extensive but generally occur below the water table. Higher fluvial, and possibly also glaciofluvial, terrace deposits such as are recognized on upper Spruce Creek and along Wilson Creek, just south of the map area, also have potential.

Placer Source Rocks

In identifying potentially productive placers settings from geomorphic and stratigraphic points of view, it is also necessary to consider the potential for bedrock in the areas to yield gold to the placer environment. A connection between altered rocks of the Atlin ophiolitic assemblage and gold quartz vein occurrences has been identified by Ash (1994, 2001). Thus, areas with the best placer potential occur downstream of areas where streams have eroded these rocks. The extent of ultramafic rocks can be determined directly from bedrock geology maps by Aitken (1959), Lefebure and Gunning (1989), Bloodgood *et al.* (1989) and Ash (1994), or indirectly from airborne magnetic data (Dumont et al., 2001a, b; Lowe and Anderson., 2002).

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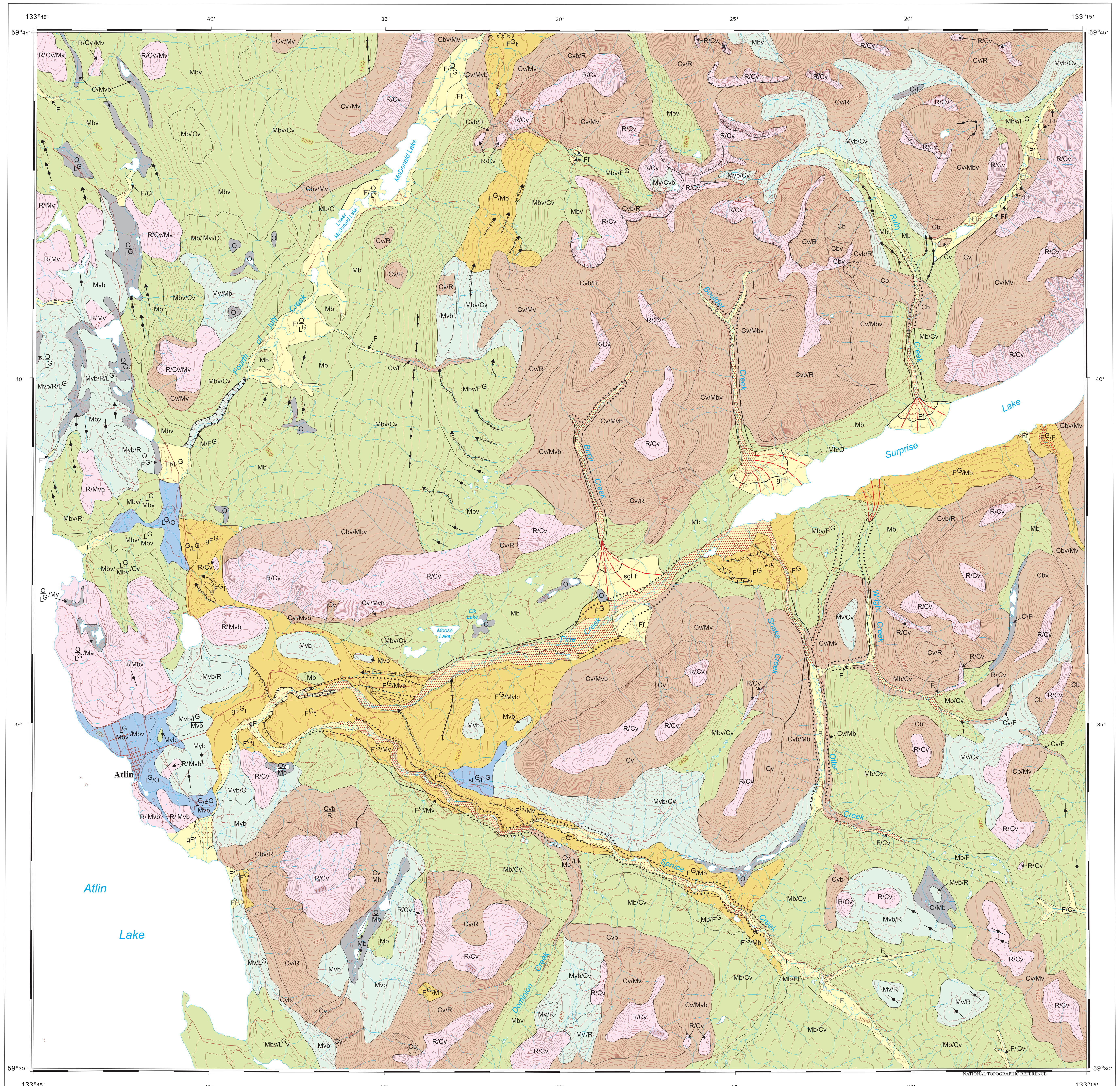

The topographic base information displayed on this map is from the British Columbia Terrain and Resource Information Management database.

QUATERNARY MATERIALS

Holocene Deposits:

O — **Organics:** material resulting from the accumulation and decay of vegetative matter; generally consists of peat and organic muds; includes bogs, swamps and marshes; occurs in poorly drained sites; often overlying glaciolacustrine sediments or clay-rich till.

F — **Fluvial sediments:** gravel, sand or silt deposited by streams and rivers; poorly to well stratified and sorted; includes floodplain and river terrace deposits (Ft) and alluvial fan sediments (Ff).

C — **Colluvium:** diamicton with variable structure and texture deposited by gravity dominated processes; generally massive and unsorted; clasts typically angular and locally derived; includes thin (< 1 m) and discontinuous veneers (Cv) of bedrock rubble and thicker (>1 m) accumulations of talus, landslide, and debris flow deposits (Cb). Colluvial veneers are commonly interspersed with bedrock outcrops (Cv/R) or morainal veneers (Cv/Mv).

Late Pleistocene Deposits:

$\mathbf{F^G}$ — **Glaciofluvial deposits:** mainly sands and gravels deposited by glacial meltwater during deglaciation; generally moderately to well stratified and sorted; includes kettled outwash, kames, eskers (see on-site symbols) and glaciofluvial deltas and terraces (F^Gt); frequently dissected by meltwater channels.

$\mathbf{L^G}$ — **Glaciolacustrine sediments**: dominantly silts, clays and fine sands deposited in glacier dammed lakes; typically horizontally stratified and well sorted; locally display features such as slump structures, ice-rafted stones and kettles; commonly occurs in low-lying areas, overlain by organics; glaciolacustrine sediments along Atlin Lake occur mainly as a discontinuous secondary unit interspersed with morainal deposits (e.g. Mbv/L^G).

Mb — **Morainal blanket:** thick till deposited by glacial ice; till is at least 1 m, but commonly several metres thick; unsorted or very poorly sorted diamicton with clasts, up to boulder size, in a clay to sand matrix; generally massive and dense; mainly occurs as an undulating till plain but locally includes drumlins, flutings and moraine ridges (see on-site symbols); commonly interspersed with glaciofluvial and glaciolacustrine sediments in valley bottoms (e.g. Mb/F^G) and higher on valley sides with till veneers (Mbv) and colluvium (Mb/Cv).

Mv — **Morainal veneer:** till deposits less than 1 m thick; diamicton similar to morainal blankets but commonly less dense and sandier in texture; surface expression controlled by the underlying bedrock topography; locally fluted; commonly occurs in mountainous areas with colluvial veneers (e.g. Mv/Cv) and as a primary component with lesser amounts of till blanket (Mvb).

R — **Bedrock:** mainly bedrock outcrop; includes areas of frost-shattered bedrock; periglacial features locally present; commonly includes discontinuous colluvial veneers (R/Cv).

Map Unit Letter Notation

surficial material → **gFt** ← surface expression
texture → **gFt**

Ov / **Mb** — The component (**Ov**) above the symbol stratigraphically overlies the one below (**Mb**)

Cbv/Mv — The component (**Cbv**) in front of the symbol is more extensive than the one that follows (**Mv**)

Surface Expression

b	blanket (> 1 metre)
f	fan
h	hummocky
t	Terrace
v	veneer (< 1 metre)

Textures

c	clay
z	silt
s	sand
g	gravel
b	boulder
d	diamicton

On-site Symbols

Drumlin, crag and tail
Fluting
Morraine ridge (major)
>>>> Esker (flow direction known)
Meltwater channel (major)
Meltwater channel (minor)
Escarpment
Cirque
Kettle

Placer Geology Legend

Areas of active and past placer mining

Areas with buried placer potential:

fluvial paleochannels (approximate, inferred)

alluvial-fan channels

Areas with Holocene placer potential:

fluvial terraces and floodplain deposits

alluvial fan deposits

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Any revisions or additional information known to the user would be welcomed by the British Columbia Geological Survey Branch and the Geological Survey of Canada.

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BRITISH COLUMBIA GEOLOGICAL SURVEY BRANCH
GEOSCIENCE MAP 2003-1

QUATERNARY GEOLOGY OF THE ATLIN AREA

BRITISH COLUMBIA

By Levson, V.M., Kerr, D.E., Lowe, C. and Blyth, H.

GEOLOGICAL SURVEY OF CANADA
OPEN FILE 1562

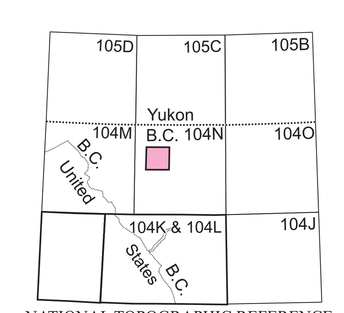
Scale: 1:50 000/Échelle 1/50 000

kilometres 1 0 1 2 3 4 kilomètres

Transverse Mercator Projection
Norht American Datum 1927

Projection transverse de Mercator
Système de référence géodésique nord-américain, 1927

Location map



NATIONAL TOPOGRAPHIC REFERENCE

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