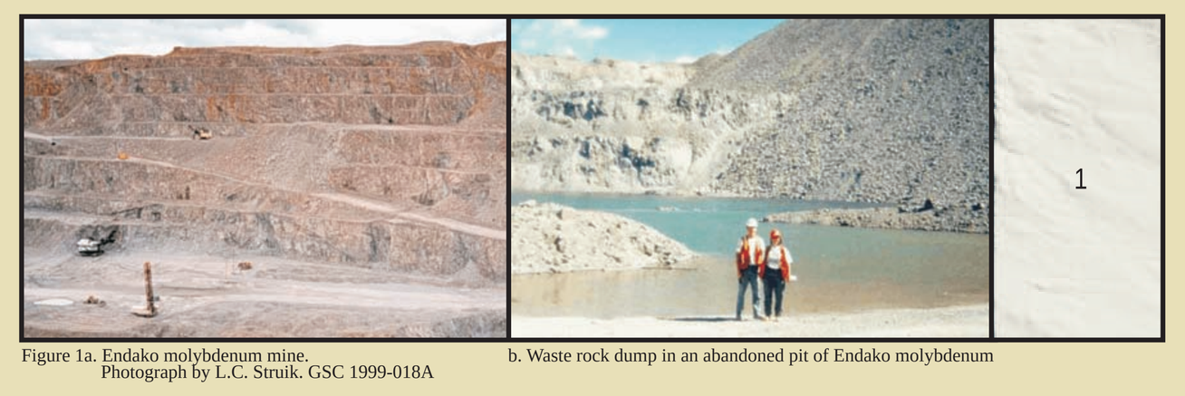
Geoscape Fort Fraser, British Columbia

Geological Survey of Canada, Miscellaneous Report 66

Geoscape Fort Fraser shows geology of the northern Nechako Plateau area of central British Columbia. The central map shows the distribution of the various types of bedrock and unconsolidated sediments in the region. Material characteristics relevant to forestry, the environment, fisheries, and land-use planning are summarized in the map legend. The surrounding thematic maps focus on particular geological issues: controls on stream productivity, the natural enrichment of mercury and molybdenum in the region, and the vulnerability of aquifers.

MODERN SEDIMENTS — Deposited from 11 000 years ago to present



1

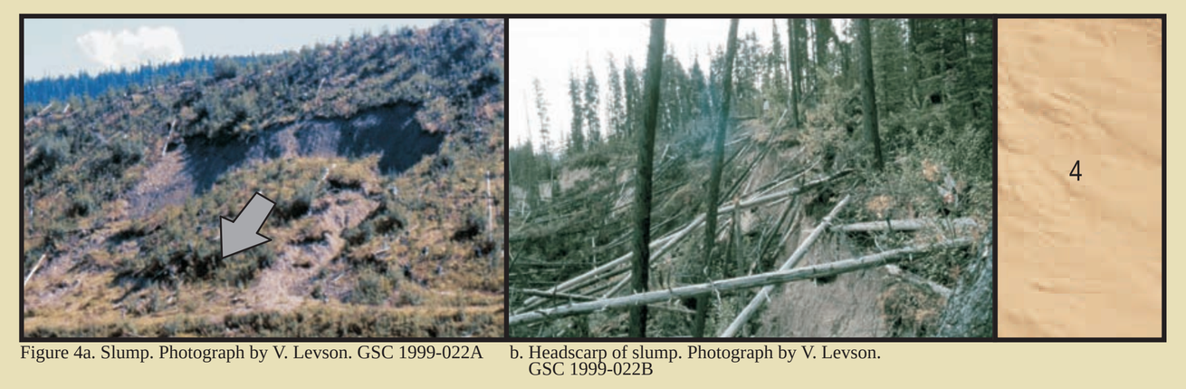
Anthropogenic terrain
These are excavations and gravel, sand, silt and/or clay of variable thickness (referred to as diamicton) emplaced by human activity. Anthropogenic terrain extensive enough to be shown on this map occurs only at the Endako mine and includes open pits,

2

Peat deposits
Organic peat and muck occur in bogs and swamps. The average thickness of organic deposits is 3 to 4 m, but the deposits can reach up to 11 m. The deposits are poor foundation material due to a low degree of consolidation and high water content. Bogs are a source of horticultural peat, although the resource has not been exploited in this

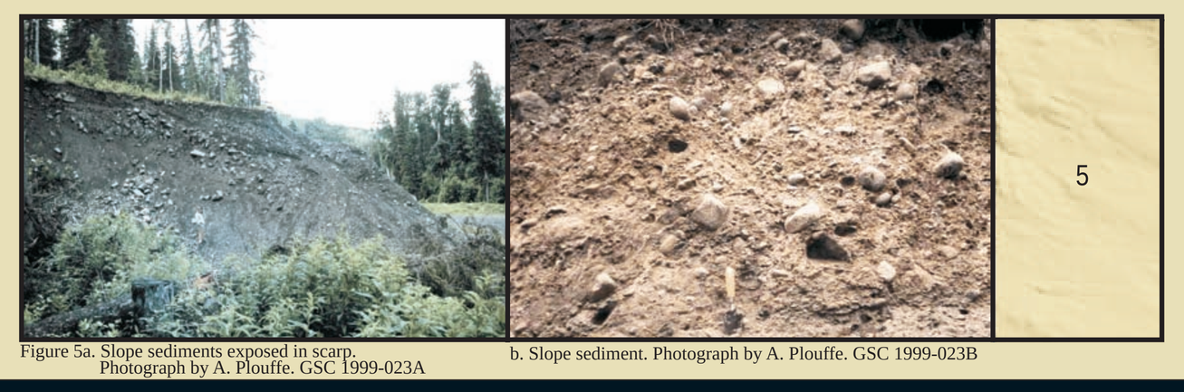
3

River sediments
Well stratified to massive sand, gravel, and minor silt and clay underlie floodplains adjacent to streams throughout the area. The deposits are generally more than 2 m thick. Sand and gravel deposits above the ground water table may be mined for aggregate. Floodplains are good agricultural land but are prone to periodic flooding in the spring and after heavy rains, and have a shallow water table. The high permeability of the sand and gravel below the water table can form important aquifers. These aquifers are often vulnerable to surface contamination.



4

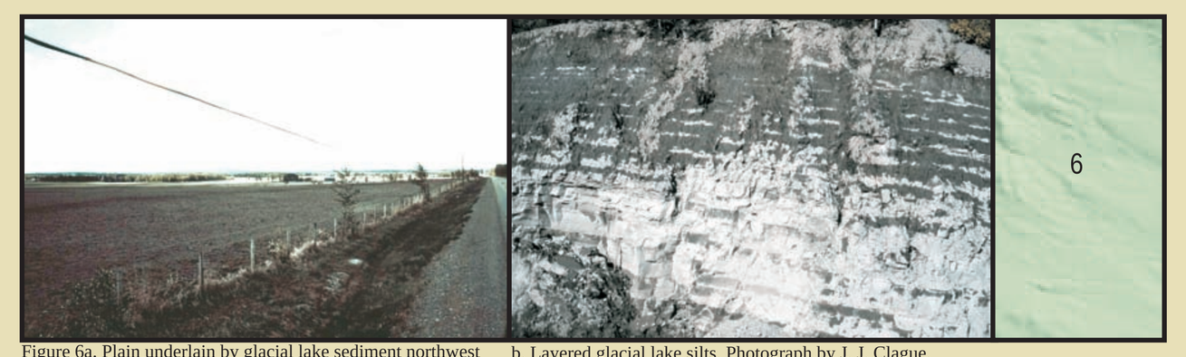
Landslide debris
Landslide deposits commonly occur on or at the base of unstable slopes. The texture and other properties of the sediment depend on the source materials and the type of landslide. The deposits are generally more than 3 m thick and have an irregular or hummocky surface. Landslides are most common along river-cut valleys, in terrain underlain by glacial lake sediments, such as the Nechako River valley. Nechako River has incised thick glacial lake silts forming unstable slopes.



5

Slope sediments
Poorly sorted sediment is deposited by slow gravitational movements and slopewash. The deposits are particularly common on steep slopes northwest of Trembleur Lake.

ICE AGE SEDIMENTS — Deposited during the last glaciation, 27 000 to 11 000 years ago



6

Glacial lake sediments
Sand, silt, and minor clay deposited in lakes during the retreat of glaciers from the region occur in mainly two areas: a corridor which extends from Trembleur Lake to Stuart River; and the Endako–Nechako valleys. Steep slopes cut by streams into glacial lake sediments are prone to landsliding and these streams have a high risk of siltation. Glacial lake deposits form excellent agricultural land because they contain few stones, have high moisture retention, and occur as relatively flat surfaces.

7

Glacial river sediments
Well sorted gravel and sand deposited by glacial meltwater streams occur mainly in the major valleys, but there are sporadic occurrences of glacial river sediments, too small to be shown on this map, on higher ground. These deposits are an excellent source of aggregate. Subsurface glacial river sediments are permeable and form

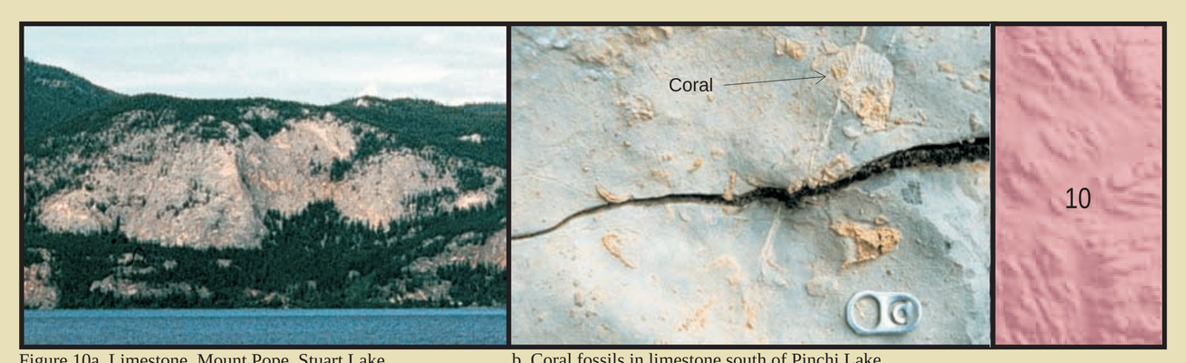
8

Glacial till
Glacial till is sediment deposited directly by glaciers, consisting of boulders, cobbles, and pebbles in a matrix of sand, silt, and clay (referred to as "diamicton"). Till is generally compacted and is a good foundation material. Where the sediment has a high clay content, such as the Stuart Lake region, steep slopes can fail if saturated with water. Till in the northeast part of the map area contains abundant limestone, and groundwater in this region has high carbonate levels ("hard water"). Locally till derived through erosion by glaciers of mercury-rich bedrock is associated with faults in the

BEDROCK — 320 to 3 million years old

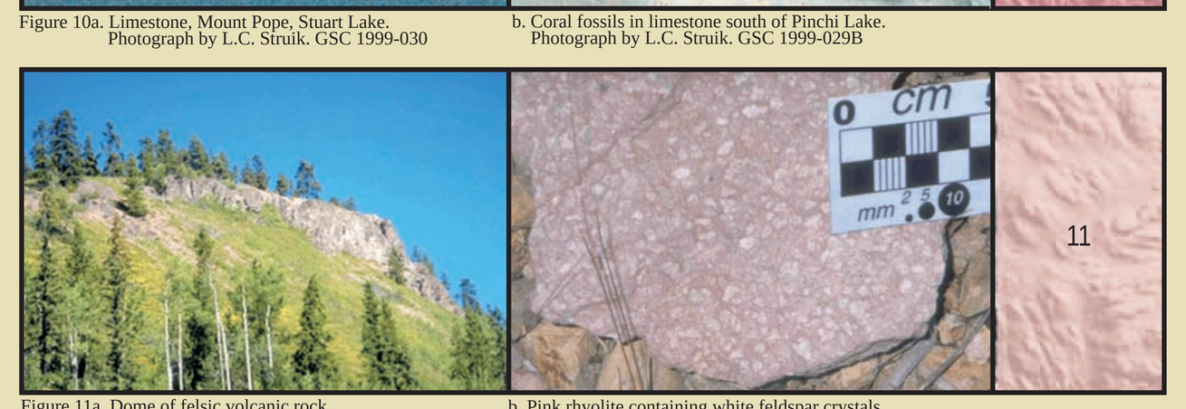
9

Sedimentary rocks
Sandstone, siltstone, shale, and conglomerate deposited in the sea 240–80 million



10

Limestone
Limestone and dolostone form long narrow ridges between Stuart and Pinchi lakes. Small areas of limestone also occur southwest of Stuart Lake and east of Toncha Lake. Limestone caves are found near Fort St. James. Some of the rocks contain beds rich in shells or corals. Streams draining limestone are more alkaline (higher pH) and more carbonate rich than streams draining other rock types. They may support larger fish populations. Limestone is quarried for road-bed fill east and west of the



11

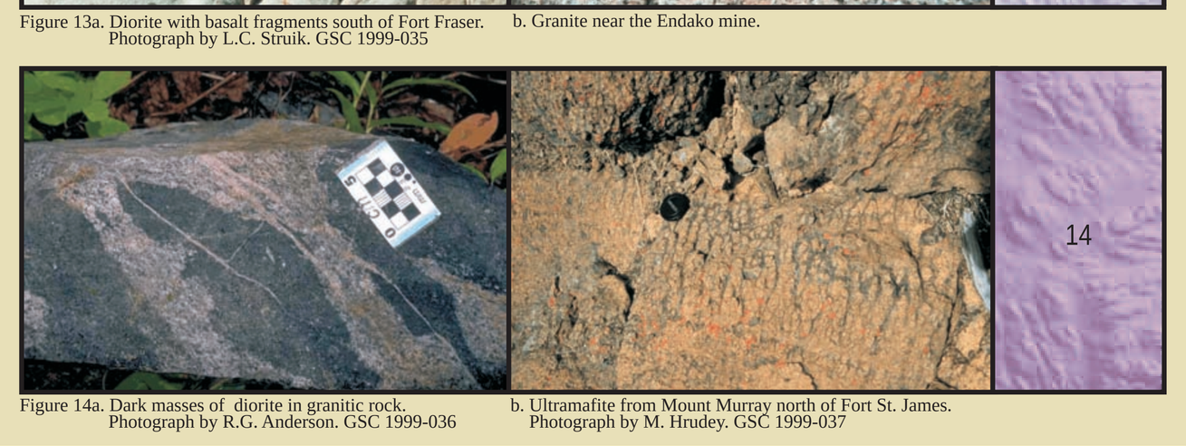
Felsic volcanic rocks
Rhyolite, rhyodacite, and dacite ranging in age from 75 to 50 million years occur as layered sequences or dykes, mainly in the southern and western parts of the map area. They are light coloured, light weight, and massive or full of bubbles (vesicles). The rocks commonly contain crystals of quartz, feldspar, biotite, and hornblende. Streams draining felsic volcanic rocks have high concentrations of phosphate and potassium, enhancing the productivity of aquatic life. Felsic volcanic rock is quarried

12

Mafic volcanic rocks
Andesite and basalt form layered sequences up to 700 m thick. These rocks are dark coloured, heavy, and massive or full of bubbles (vesicles) and formed from volcanic flows similar to those occurring today at Hawaii. The rocks date to four periods: 280–247, 230–190, 70–47, and 27–11 million years ago. Some have conspicuous cooling joints (columnar joints) or contain fragments of sandstone or red basalt. Volcanic rocks are chemically reactive, and streams draining them have elevated concentrations of important nutrients such as phosphate. Some of the younger mafic volcanic rocks contain opal and agate. Quarries at Fraser Lake west of Fort Fraser

13

Felsic plutonic rocks
Light coloured, coarse-grained igneous rocks including granite, monzonite, and granodiorite. They consist of interlocking masses of quartz, potassium and sodium feldspars, biotite, and hornblende. Felsic plutonic rocks range in age from 220 to 60 million years. The rocks are mostly massive and structureless, but some have a planar or linear orientation of crystals. Some felsic granitic rocks around Fraser, Burns, and Camsell lakes contain deposits of molybdenum, copper, lead, silver, and gold. Groundwaters flowing through granitic rocks tend to be acidic (pH 4–7) and



14

Mafic plutonic rocks
Gabbro and ultramafite are 320 to 200 million years old and are concentrated along a wide northwest-trending zone that extends from Pinchi Lake to Mount Sidney Williams. The rocks are dark coloured and consist of interlocking crystals of calcium feldspar, hornblende, pyroxene, and/or olivine. They may contain deposits of chrome, nickel, antimony, and platinum. The rocks are mostly massive and structureless, but some

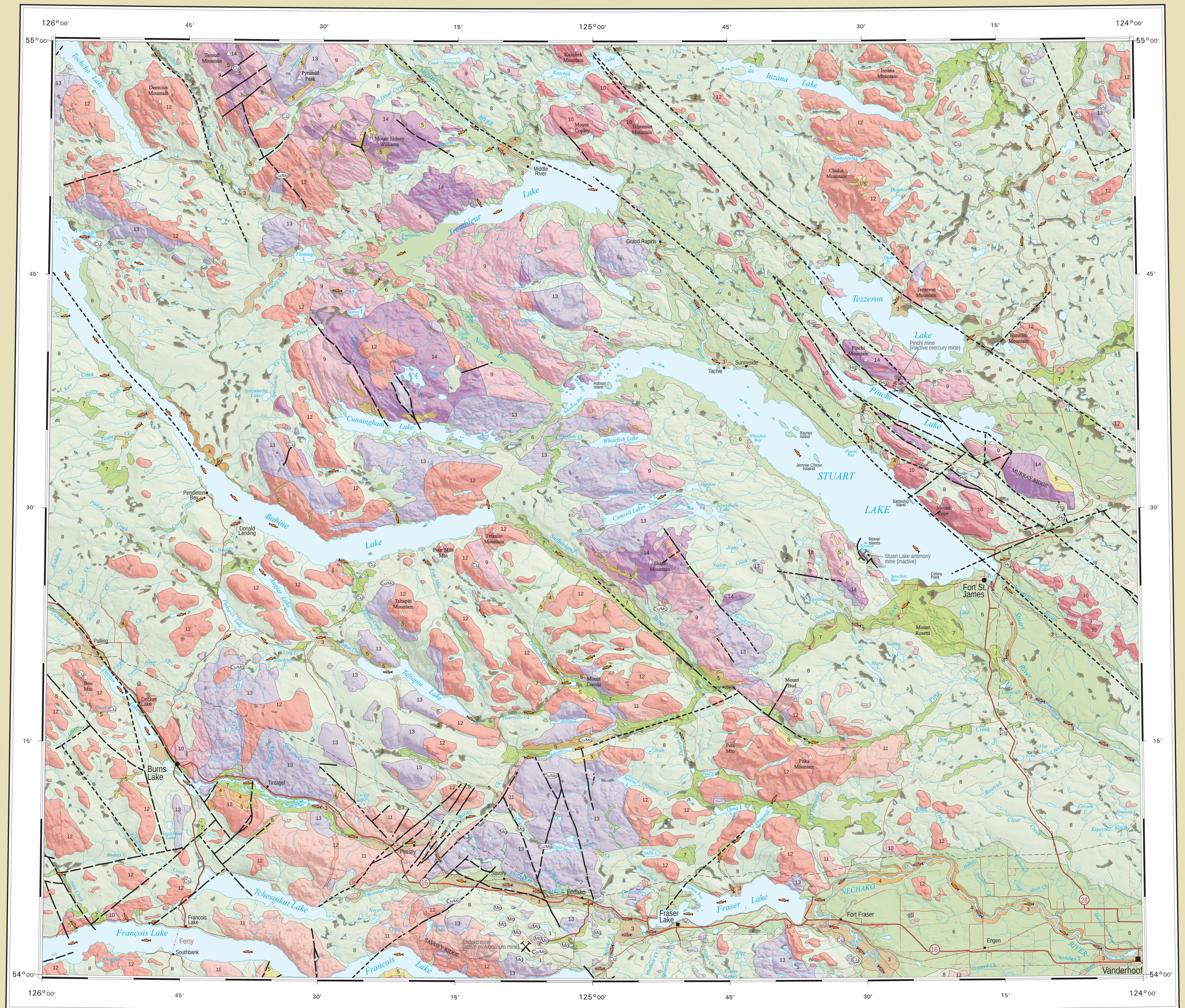


Figure 15. Geological map

For description of geological units on this map, see illustrated map legend and colour key on panels to left

Landforms left by glaciers

Climatic fluctuations during the Pleistocene Epoch (2 000 000 to 10 000 years ago) caused glaciers to grow and decay. As the last ice sheet that covered British Columbia retreated at the end of the Pleistocene, it left behind many distinctive landforms and sediments.

During the last glaciation, east-flowing glaciers scoured the bedrock and deposited **till**, a poorly sorted sediment containing stones up to boulder size. Till blankets flat to moderately sloping terrain above the valley floor. Elongate and spoon-shaped hills of glacial debris (**drumlins)** are oriented parallel to the direction of glacier flow.

Streams of meltwater flowed through tunnels within, beneath, and on the glaciers. Sand and gravel accumulated in these tunnels, forming long, narrow, sinuous ridges (**eskers**). The ridges are an excellent source of sand and gravel. Where meltwater streams flowed away from the ice front, they deposited sand and gravel as **outwash fans** and **outwash plains**. Isolated and buried ice blocks in the outwash melted to form depressions known as **kettles**. Meltwater was also dammed in places by ice or sediments, forming **glacial lakes**. When the ice sheet disappeared, the lakes drained, leaving behind nutrient-rich silty and clayey sediments that form some of the best agricultural land in central British

Figure 16a. End of glaciation (12 000 years ago)

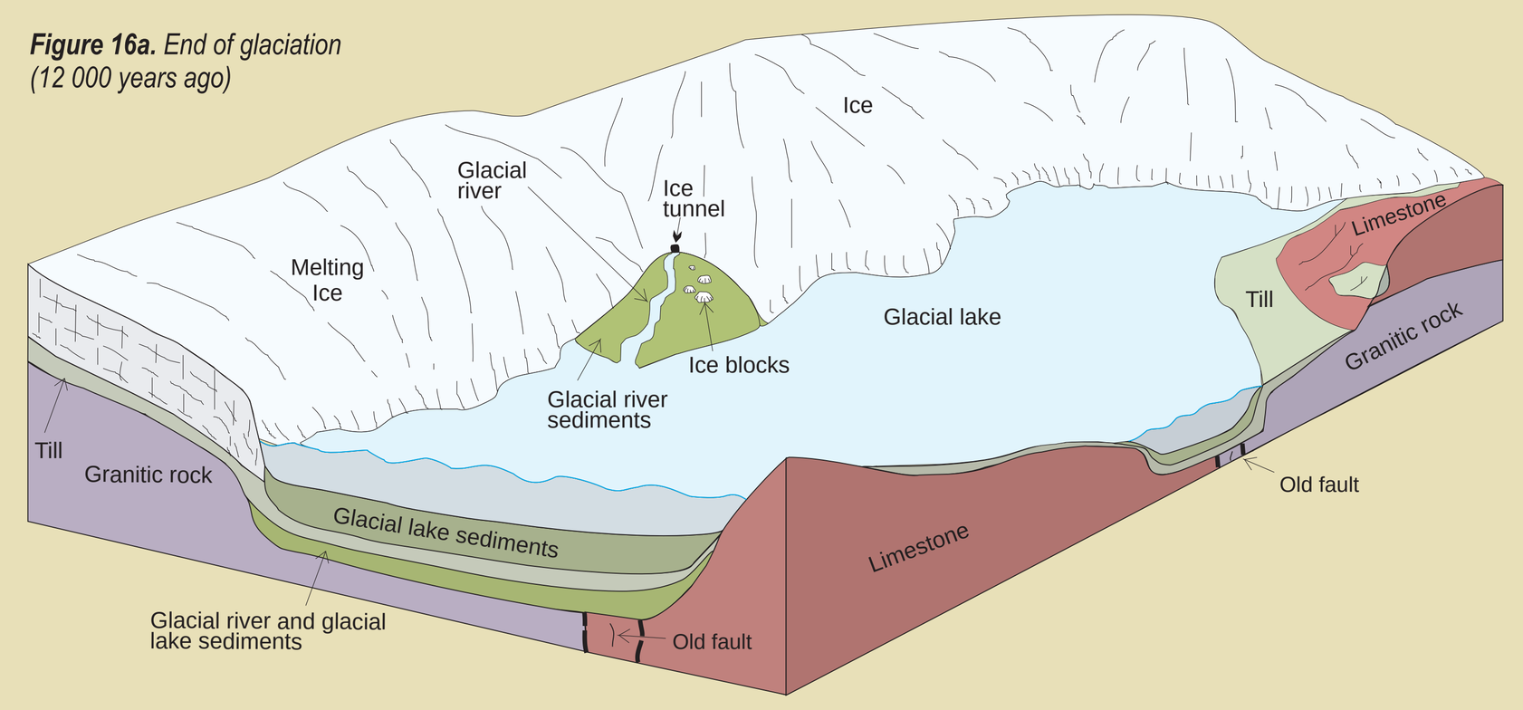
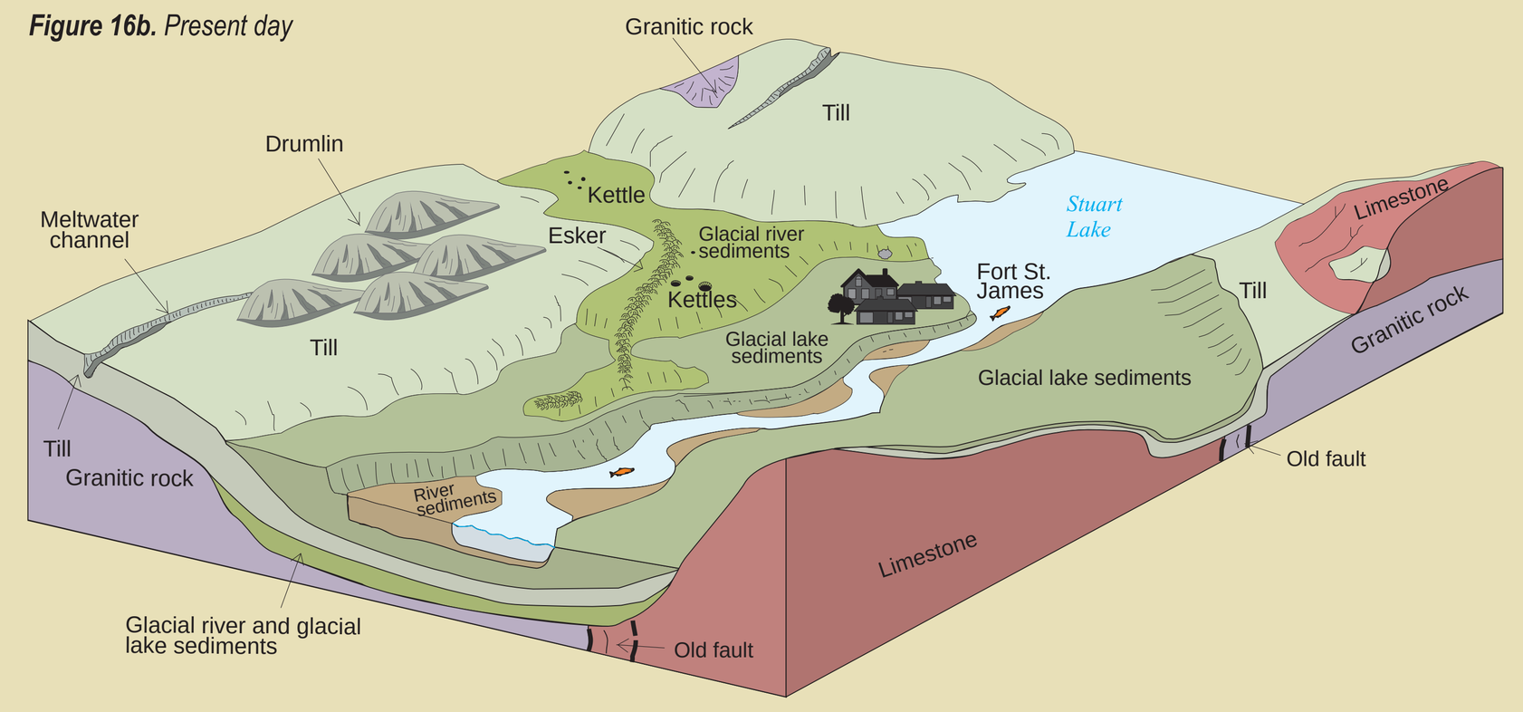


Figure 16b. Present day



Mercury in the environment

The Pinchi Fault crosses the northeastern Fort Fraser map area and has a total length of 470 km. Minerals enriched in mercury occur naturally along the fault and were deposited by ancient hot fluids. The Pinchi and Takla Bralorne mines, the only two mines (now inactive) to have produced mercury in Canada, were located along the Pinchi Fault. Mercury concentrations in till are extremely high near both mines and are high at other localities up to several kilometres east of the fault. During the last glaciation, glaciers eroded bedrock and sediments which were enriched in mercury and were transported in an easterly or down-ice direction.

The areal extent of high mercury concentrations in till, on the scale of kilometres, is much greater than the extent of the mercury mineralization in bedrock, which occurs on the scale of tens or hundreds of metres, along the Pinchi Fault. Geologists look for these large anomalous zones in till and then trace them "up-ice" to their bedrock source.

The presence of mercury in central British Columbia is of particular interest because of its economic value and environmental impacts. Natural processes convert small amounts of mercury to the highly toxic methyl mercury form. Fish and other wildlife can accumulate methyl mercury in their muscle tissues and other parts of their system. Human consumption of these animals in sufficient quantity can lead to health problems.

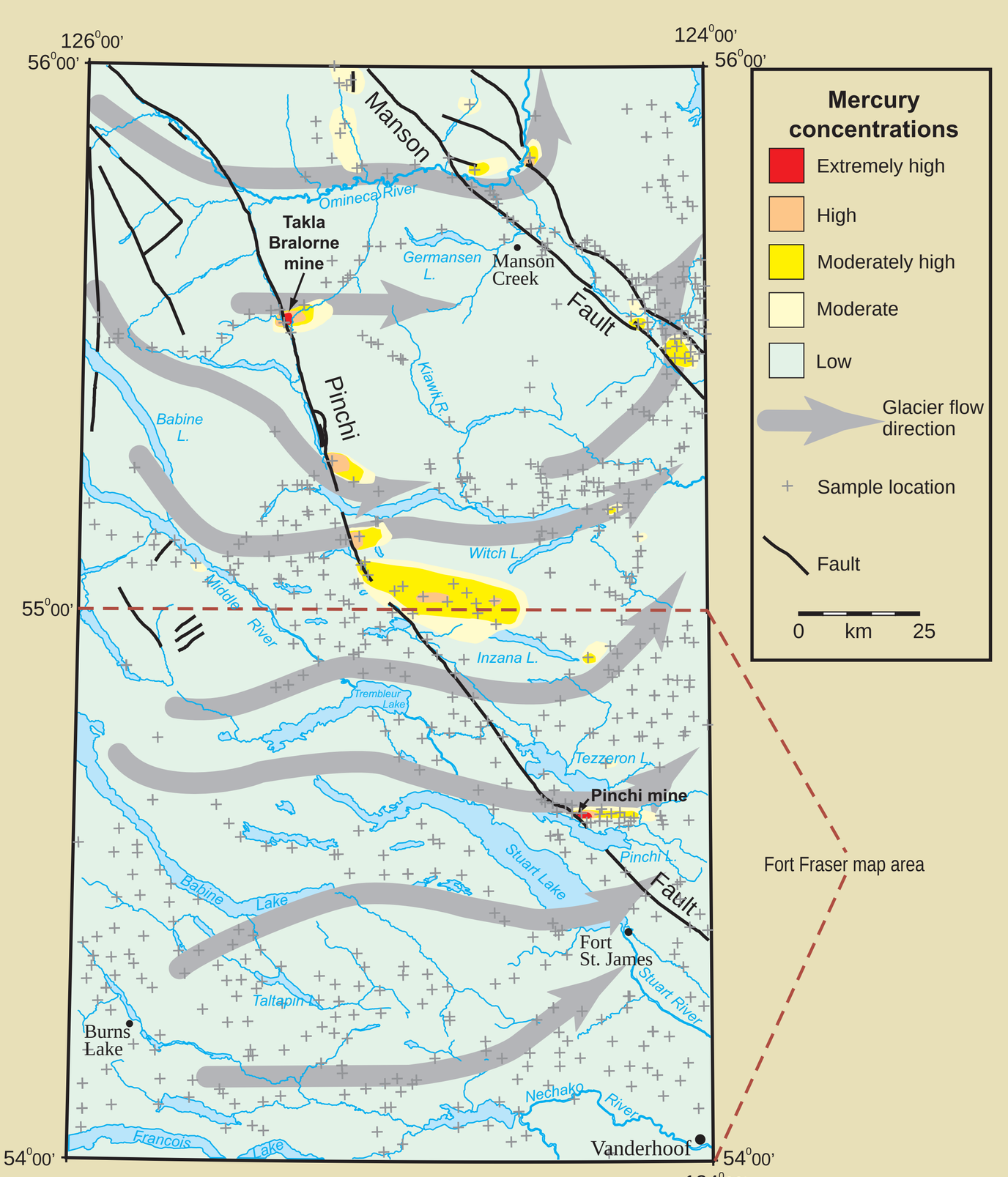


Figure 17. Mercury in till, central British Columbia

Groundwater: vital but vulnerable

Groundwater is an important resource in the Fort Fraser map area because it is used in many homes and for livestock.

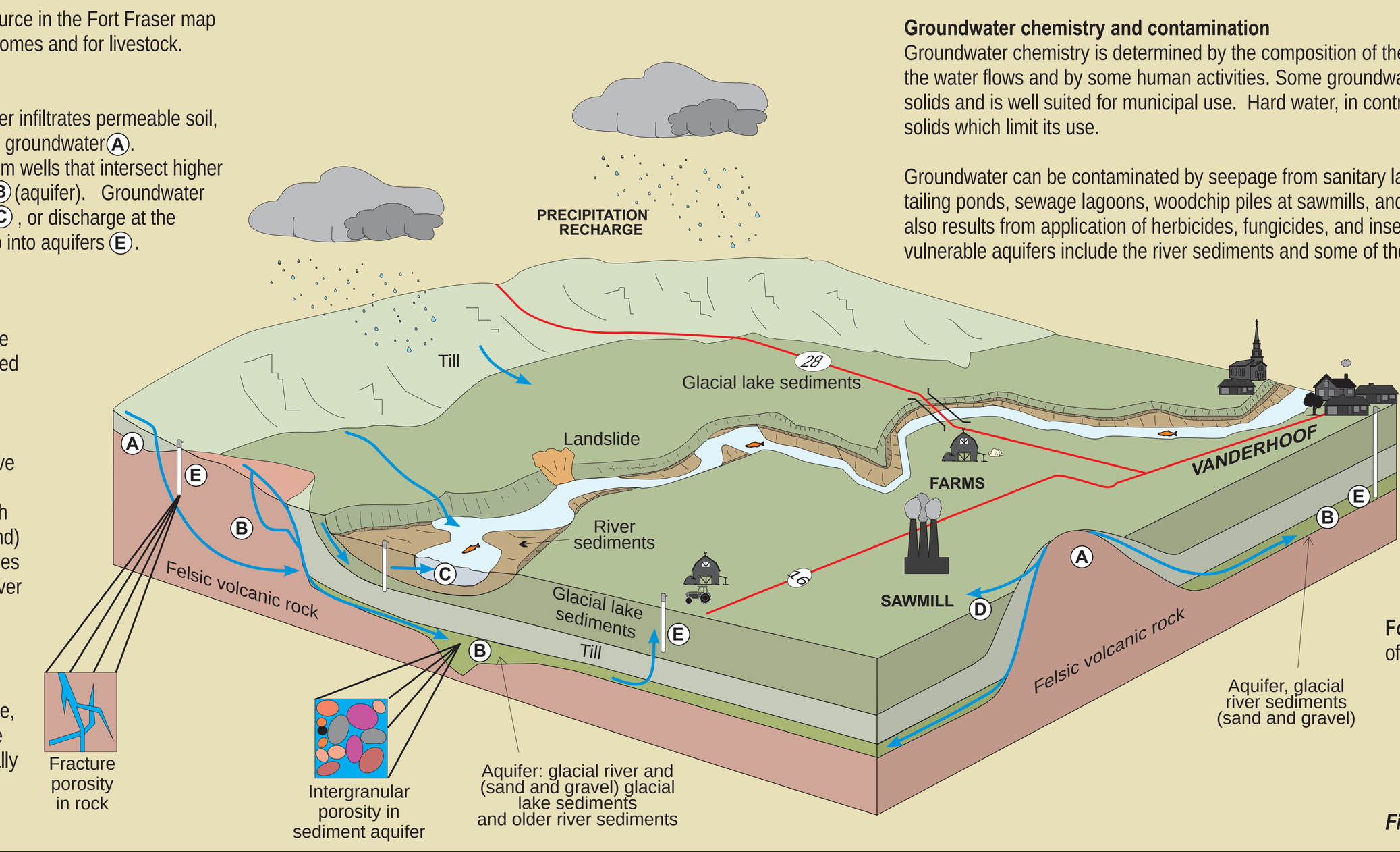
What is groundwater?
When precipitation or surface water infiltrates permeable soil, sediments or bedrock, it becomes groundwater (A). Groundwater can be produced from wells that intersect higher porosity and permeability zones (B) (aquifer). Groundwater may flow into streams and lakes (C), or discharge at the surface as a spring (D). Wells tap into aquifers (E).

Groundwater resources
The most important **aquifers** in the Fort Fraser map area are comprised of sand and/or gravel found in modern river sediments and older glacial and nonglacial deposits. Most of the wells in this region have low yields (less than one litre per second), but there are several high yield wells (tens of litres per second) near Vanderhoof and Fort St. James that produce from buried glacial river sand and gravel aquifers.

Most groundwater in the region is moderately to very hard. Concentrations of iron, manganese, and uranium in groundwater in the Endako and Burns Lake area locally exceed recommended concentrations.

Groundwater chemistry and contamination
Groundwater chemistry is determined by the composition of the bedrock and sediments through which the water flows and by some human activities. Some groundwater has low concentrations of dissolved solids and is well suited for municipal use. Hard water, in contrast, contains high levels of dissolved solids which limit its use.

Groundwater can be contaminated by seepage from sanitary landfills, chemical spills, manure piles, mine tailing ponds, sewage lagoons, woodchip piles at sawmills, and buried industrial tanks. Contamination also results from application of herbicides, fungicides, and insecticides to agricultural land. The more vulnerable aquifers include the river sediments and some of the unconfined glacial river sand and gravel



PRECIPITATION RECHARGE
Till
Glacial lake sediments
Landslide
River sediments
FARMS
VANDERHOOF
SAWMILL
Felsic volcanic rock
Glacial lake sediments
Till
Fracture porosity in rock
Intergranular porosity in sediment aquifer
Aquifer: glacial river and (sand and gravel) glacial lake sediments and older river sediments
Aquifer, glacial river sediments (sand and gravel)

For more information see the B.C. Ministry of Environment, Lands and Parks web site at

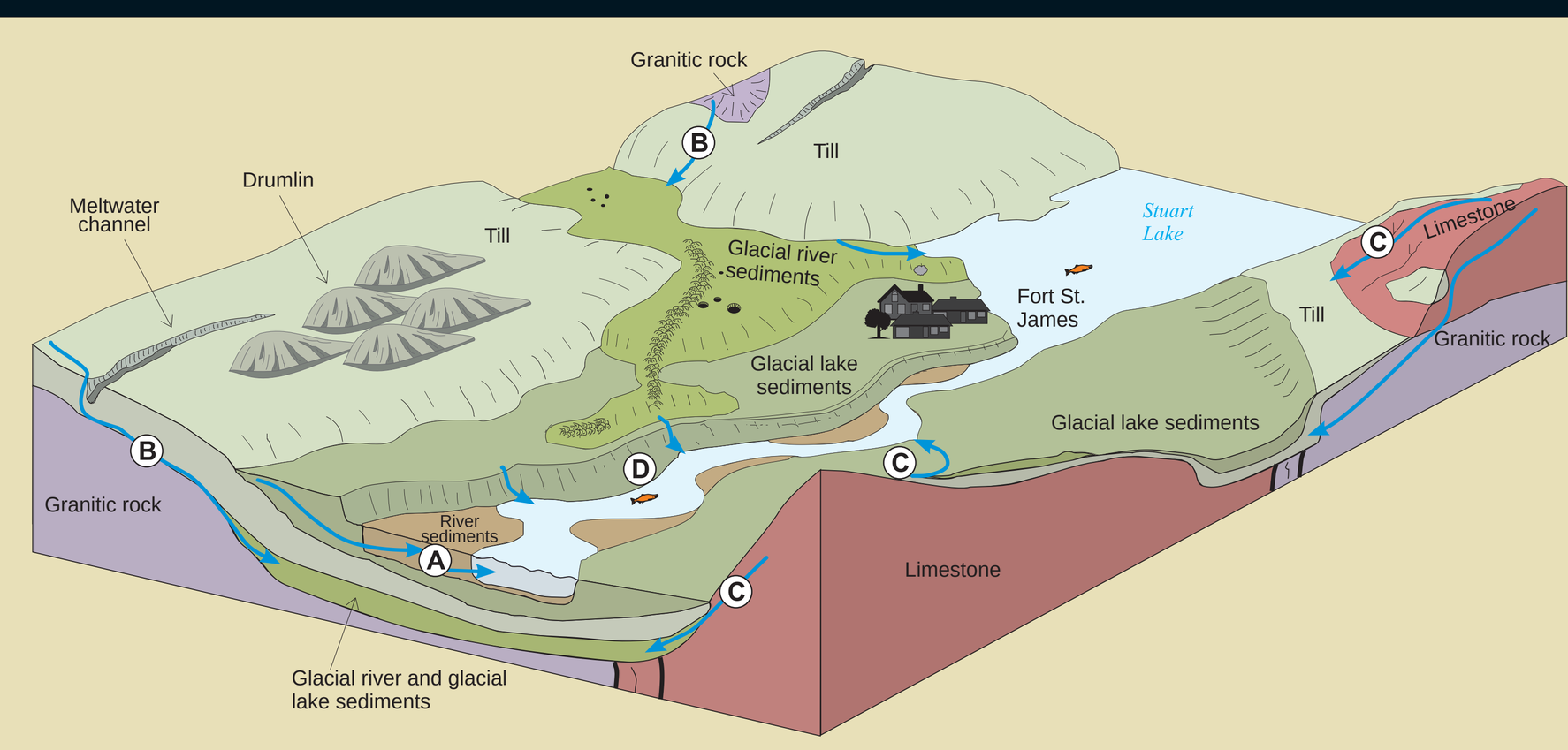
Figure 18. Groundwater resources

Geological controls on fish habitat

The headwaters of the Fraser and Skeena rivers occur in the Fort Fraser map area. Large numbers of Pacific salmon spawn in streams in these headwater areas. Lakes and streams feeding the Stuart and Nechako rivers host salmon that have travelled up the Fraser River, and lakes and streams feeding Babine Lake and Babine River host salmon that have travelled up the Skeena River.

The map area has abundant habitat for fresh water and spawning marine fishes. Factors that influence the quality of the fish habitat include water temperature, water chemistry, and the stream sediment load.

Water temperature
Pacific salmon prefer cool waters. In summer and fall, when salmon spawn, groundwater is generally cooler than surface water. Groundwater discharge into lakes and rivers (A) maintains cooler water temperatures during hot weather. Without groundwater inflow, stream temperatures could reach levels harmful to salmon.



Water chemistry
Fish prefer neutral to alkaline waters. Surface water and groundwater are generally more acidic in areas underlain by granitic rock (B) than in areas of limestone (C).

Sediment load
Fish spawning habitat can be damaged if streams deposit silt in their channels. Sediment in streams in the Fort Fraser map area is primarily derived from glacial river deposits (sand and gravel), till, and glacial lake sediments (sand, silt and clay). Natural siltation is highest in areas where streams cut into banks of glacial lake sediments, such as along the Stuart and Nechako (D)

Figure 19. Geological controls on fish habitat

Earth material characteristics

Table 1. Earth material characteristics

Map unit	Material	Thickness	Permeability	Erodability	Stability	Aquifer potential	Water quality	pH buffering potential	Aggregate potential	Morphology
Peat deposits	Peat	1–3 m	Low to high	Low	Low	Low	Low	Low	nil	Flat
River sediments	Sand, gravel, silt	2–10 m	High	Variable	Medium	Medium	Medium to high	Low	Medium to high	Flat (floodplain, terrace)
Landslide debris	Diamicton, rubble, silt	1–5 m	Medium	Low to high	Low	Low	na	Low	Low	Hummocky
Slope sediments	Diamicton, sand, gravel	1–5 m	Medium	Variable	Medium	Low	na	Low	Variable	Inclined, rolling
Glacial lake sediments	Silt, clayey silt, fine sand	1–30 m	Low to medium	High	Low	Low to moderate	High	Medium	Low	Flat, rolling, gullied
Glacial river sediments	Sand, gravel	1–10 m	High	Medium	Medium	High	High	Low	High	Flat, hummocky
Glacial till	Diamicton	1–10 m	Low	Low	High	Low	na	Low, except in northeast	Low	Rolling
Sedimentary rocks	Sandstone	na	Low	Low	High	Low	na	Low	Low	Hilly, mountainous
Limestone	Limestone, dolostone	na	Medium	Low	High	Medium	Medium	High	Medium	Hilly, mountainous
Felsic volcanic rocks	Rhyolite, dacite	na	Low	Low	High	Low	na	Low	Rhyolite medium	Hilly
Mafic volcanic rocks	Basalt	na	Low	Low	High	Low	na	Low	High	Hilly, mountainous
Felsic plutonic rocks	Granite, diorite	na	Low	Low	High	Low	na	Low	Low	Hilly, mountainous
Mafic plutonic rocks	Gabbro, ultramafite	na	Low	Low	High	Low	na	Low	Ultramafic moderate	Hilly, mountainous

na - not applicable

Physiography

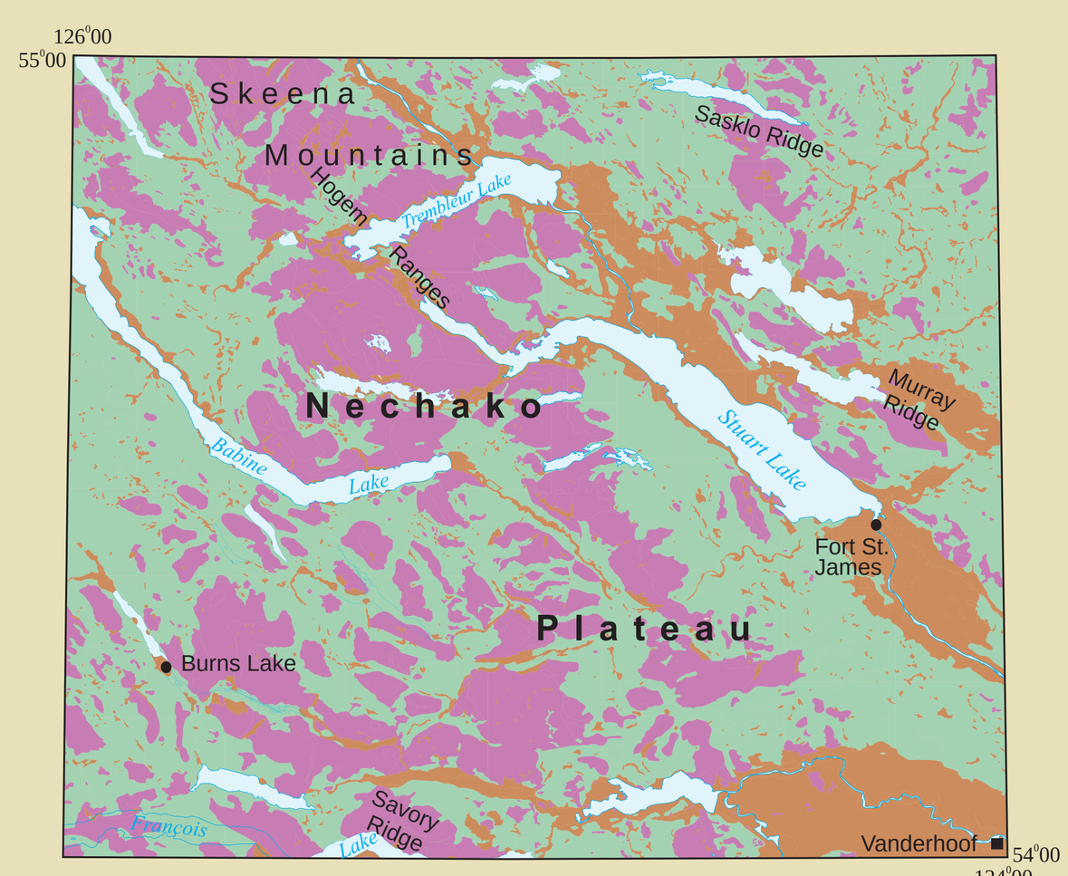
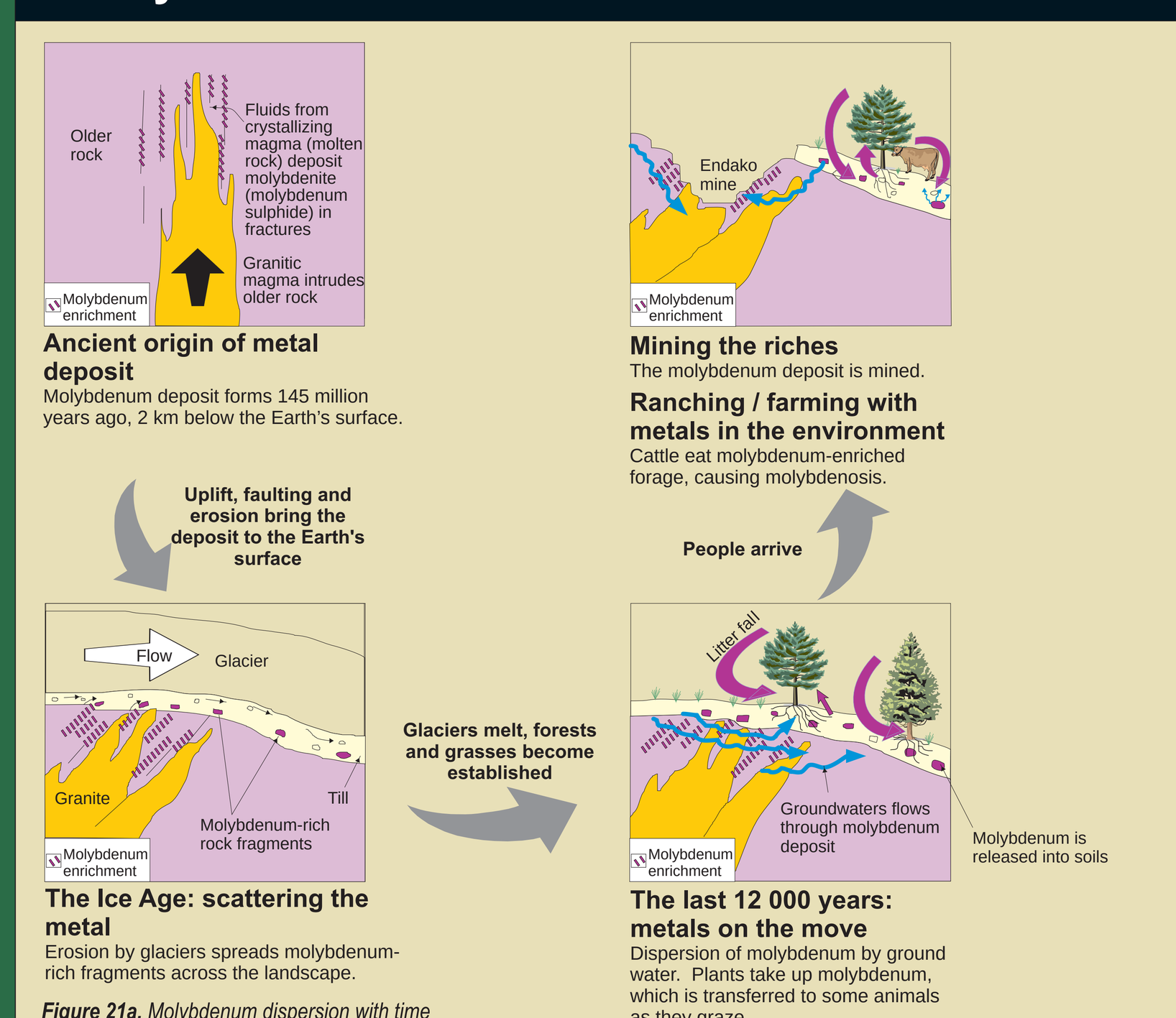


Figure 20. Physiography is the surface form of the Earth. Fort Fraser map area includes flat and rolling **lowlands**, rolling **uplands**, and low-lying **mountains**. The mountains increase in elevation to the north. Uplands of glacial till and glacial river sediment flank the mountains. **Lowlands** are areas of glacial lake sediment cut by modern rivers and creeks.

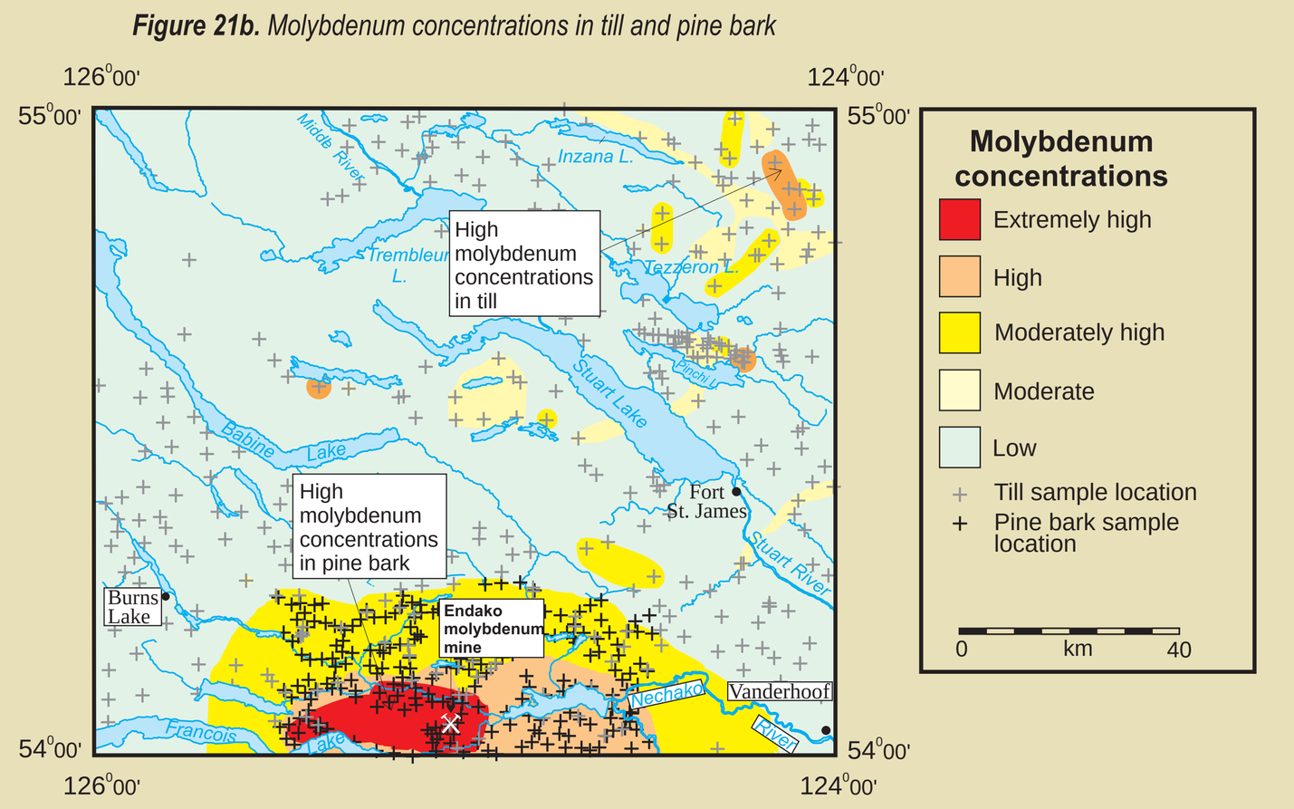
Molybdenum in the environment



Ancient origin of metal deposit
Molybdenum deposit forms 145 million years ago, 2 km below the Earth's surface.
Mining the riches
The molybdenum deposit is mined.
Ranching / farming with metals in the environment
Cattle eat molybdenum-enriched forage, causing molybdenosis.
Uplift, faulting and erosion bring the deposit to the Earth's surface
People arrive
Glaciers melt, forests and grasses become established
Molybdenum-rich rock fragments
Molybdenum enrichment
Molybdenum is released into soils
The Ice Age: scattering the metal
Erosion by glaciers spreads molybdenum-rich fragments across the landscape.
The last 12 000 years: metals on the move
Dispersion of molybdenum by ground water. Plants take up molybdenum, which is transferred to some animals as they graze.

Figure 21a. Molybdenum dispersion with time

Figure 21b. Molybdenum concentrations in till and pine bark



Molybdenum concentrations
Extremely high
High
Moderately high
Moderate
Low
Till sample location
Pine bark sample location
High molybdenum concentrations in pine bark
Endako molybdenum mine
Burns Lake
Fort St. James
Vanderhoof
Nechako River
Stuart River
Francois Lake
54°00'
126°00'
124°00'
0 km 40

MOLYBDENOSIS
Cattle that ingest too much molybdenum are unable to absorb sufficient copper from their food. Copper deficiency can cause growth and reproductive problems. This disorder is termed molybdenosis and can be treated by injecting the cow with a copper supplement.

Molybdenosis in cattle is linked to 1) soils with high molybdenum concentrations; 2) grazing on legumes (clover, pea-vine) rather than grass (grasses absorb less molybdenum than legumes); 3) alkaline soils, which

Additional information

Geoscape Fort Fraser, British Columbia

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- *Digital Cartography and GIS compilation*: N. Hastings, and S.P. Williams
- *GRID™ compilation*: R. Kung

Geoscape Fort Fraser, British Columbia is available from Geological Survey of Canada offices:

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V6B 5J3	K1A 0E8	T2L 2

Website: www.nrcan.gc.ca/gsc/

Helpful review of draft versions of Geoscape Fort Fraser was provided by Carol Ann McDevitt, Colin Dunn, Mike Wei, Kevin Ronneseth, and Robert Garrett.

Geoscape Fort Fraser is based on the following bedrock and surficial geology maps:

Bedrock geology maps:
Bellefontaine, K., Legun, A., and Massey, N.
1997: Geological compilation of northeast British Columbia, southern half, NTS 93K; B.C. Geological

Struik, L.C.
1998a: Bedrock geology, Tezzeron map area, British Columbia (part of 93K); Geological Survey of Canada, Open File 3624, scale 1:100 000.
1998b: Bedrock geology of the Fraser Lake map area, British Columbia (93K/SE); Geological Survey of Canada, Open File 3559, scale 1:100 000.

Struik, L.C. and Whalen, J.B.
1998: Bedrock geology, Endako, central British Columbia (93 K/3); Geological Survey of Canada, Open File 3630, scale 1:50 000.

Surficial geology maps:
Plouffe, A.
1994: Surficial geology, Tezzeron Lake, British Columbia; Geological Survey of Canada, Open File 2846, scale 1:100 000.
1998a: Surficial geology, Burns Lake, British Columbia; Geological Survey of Canada, Open File 3184, scale 1:100 000.
1998b: Surficial geology, Cunningham Lake, British Columbia; Geological Survey of Canada, Open File 3183, scale 1:100 000.
1998c: Surficial geology, Fraser Lake, British Columbia; Geological Survey of Canada, Open File 3182, scale 1:100 000.

Other publications of interest:
Plouffe, A.
1995a: Geochemistry, lithology, mineralogy and visible gold grain content of till in the Manson River and Fort Fraser map areas, central British Columbia (NTS 93K and N); Geological Survey of Canada, Open File 3194, 119 p.
1995b: Glacial dispersal of mercury from bedrock mineralization along Pinchi Fault, north central British Columbia; Water, Air and Soil Pollution, v. 80, p. 1109–1112.

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1999: Geoscape Fort Fraser, British Columbia; Geological Survey of Canada, Miscellaneous Report 66, 1 sheet.