

Striae

(bi-directional)

(bi-directional)

Craig and Tail

Melt Water Channel

(uni-directional)

exposures, a general coarsening upwards succession is observed, often

capped by a massive unit of clay or silt. This succession most notably

occurs in the major valleys, underlying fluvial and glaciofluvial terraces.

MORAINAL: Poorly sorted, moderate to well compacted, clayey to silty

boulders and may be faceted and/or striated. Interpreted as lodgement till.

subaqueously or in association with flowing water. At higher elevations, in

the northeast region of the map sheet, less compact, boulder rich ablation till

BEDROCK: Quesnel Terrane, upper Triassic to lower Jurrasic rocks related

to a volcanic arc.

Pre-Quaternary

Irregular sand and gravel lenses may be present where till was deposited

diamicton. Clasts are subrounded to subangular, range from pebbles to

low-lying, poorly drained areas.

found within the floodplains.

FLUVIAL: Cobble gravel with sand matrix associated with the avulsion of

water courses. Sediment is deposited in gravel bars and low fluvial terraces.

In subordinate valleys, fluvial sediments, consisting of fine to coarse sand

COLLUVIUM: Poorly sorted, sandy to gravelly diamicton with weak to

weakly moderate compaction. Where colluvial deposits are the result of

mass wasting of glaciolacustrine sediment, they tend to be clay or silt rich

and contain organic debris. At the base of steep rock cliffs, colluvium is

typically talus, composed of angular, cobble or boulder clasts.

Ministry of Energy and Mines Mines and Minerals Division Geosciences, Research and **Development Branch**



OPEN FILE 2003-7

QUATERNARY GEOLOGY OF THE HYDRAULIC MAP SHEET (NTS 93 A/12) **BRITISH COLUMBIA**

A.J. Bichler, University of Victoria P.T. Bobrowsky, Geological Survey of Canada

Scale 1:50 000

INTRODUCTION

Surficial geology of the Hydraulic map sheet (NTS 93A/12) was mapped in partial fulfilment of a Master's of Science thesis being conducted at the University of Victoria and in association with the British Columbia Geosciences, Research and Development Branch and the Geological Survey of Canada. The region was mapped at a scale of 1:50 000, using 1:40 000-scale, black and white, vertical aerial photographs (15BCB960011, 15BCB98020, 15BCB98021 and 15BCB98023).

Mapping methodology followed the Guidelines and Standards for Terrain Mapping in British Columbia (British Columbia Resource Inventory Committee 1996) and the Terrain Classification System for British Columbia (Howes and Kenk 1997). The study area was divided into terrain units based on the surficial material, geomorphic attributes, and geologic/geomorphic processes found within their boundaries. Each enclosed terrain unit, or terrain polygon, represents a homogeneous parcel of land with respect to its inherent attributes.

Three hundred and twenty eight terrain polygons were identified of which 104 were ground-truthed by 137 field stations. This yields approximately 32% of the polygons verified and corresponds to a Terrain Survey Intensity Level (TSIL) C as described by the British Columbia Resource Inventory Committee (1996). For all field stations, location and a description of the surficial material including its type, texture, thickness and geomorphic

Fieldwork for surficial mapping and stratigraphy was conducted in 2001, making use of an extensive network of logging roads in addition to using a boat along the Quesnel and Cariboo Rivers. Most of the major stratigraphic sections are located along these rivers, as well as within an excavated, buried channel (Bullion Pit) that contains the most complete known stratigraphic sequence in the region (refer to Clague et al. 1990). In total, 21 stratigraphic sections were logged in detail and are discussed by Bichler (2003).

DESCRIPTION OF STUDY AREA

The study area is located approximately 50 kilometres southeast of Quesnel, near the township of Likely, British Columbia. The region is known for its long history of placer mining that began during the 1860's. During this time, the township of Quesnel Forks, located at the confluence of the Quesnel and Cariboo Rivers, was a major centre, housing more than 5000 people at its peak. Today, many of the original buildings are still

The mapped area lies on the eastern edge of the Interior Plateau at the boundary of the Quesnel Highlands and the Fraser Plateau. The distinction between the highland and plateau regions is somewhat arbitrary. In general, the area is characterized by flat and gently rolling topography with large undissected uplands (Holland 1976). The highest point within the study area is approximately 1560 metres asl and the lowest point is 600 metres asl. On average, the plateau lies at 940 metres asl.

The major drainage in the region is provided by the Quesnel and Cariboo Rivers, which drain the Quesnel and Cariboo Lakes (northeast of mapped area), respectively. The Quesnel River valley is an east-west trending topographic low that is on average 280 metres deep and approximately 1.5 kilometres wide. Flow within the valley is to the west. The river drops 90 metres in elevation over a distance of 32 kilometres. The Cariboo River valley also trends east-west and is similarly incised, though narrower.

Sub-boreal spruce zone occupies the majority of the region up to an elevation of 1300 metres asl, whereas at higher altitudes the Engelmann spruce-subalpine fir zone dominates (Meidinger and Pojar 1991). The primary soils belonging to these zones are luvisols, podzols, and brunisols. Seasonal extremes typify the climate with severe snowy winters contrasting relatively warm, moist summers. The area experiences a moderate annual precipitation (Meidinger and Pojar 1991), on average 690 mm per year with approximately 70% being rain.

Thick glaciogenic sediments mantle most of the surface. Bedrock of the Quesnel Terrane outcrops are most common in the north-east and southern areas of the map sheet, as well as in the major valleys on south facing

SURFICIAL GEOLOGY

Much of the surficial material in the study area can be attributed to the Fraser Glaciation of the Late Wisconsin Over the plateau, till is the most dominant surficial material. Morainal terrain units make up 86% of the entire mapped area. Till typically occurs as a thick blanket (>1 m thick) that masks local topography. It is poorly sorted, moderate to well-compacted, silty clay diamicton. At surface the till is often heavily washed, with the fine-grained component removed by weathering and erosion. These deposits are interpreted as lodgement till, except at higher elevations north of the Quesnel River in the eastern part of the map sheet where till is less compact, boulder rich, and has a sandy matrix. There, deposits are interpreted as ablation till.

Many streamlined landforms occur in association with ground moraine, in which flutings are most common, especially in the northeast map quadrant. Flutings are up to 1.5 km in length and 100 m wide. They are readily identifiable from airphotos where flute ridges are forested and depressions between adjacent flutes are dominated by fens. Within logged areas, these depressions show a dark tonal change that is indicative of organic rich soil and high moisture content. Flutings have a mean bi-directional orientation of 315° or 45°. In the southeastern region, their orientation has a stronger east-west component ($ca.300^{\circ}$), with an increasing north-south orientation in the northwest (ca. 330°).

Drumlins, drumlinoid ridges, and craig and tail features are less common but occur in similar regions as flutings. These features have orientations on average 308° but also range from 300° to 330°. These streamlined forms are generally shorter than flutings, up to 500 m in length, and have similar widths.

Glaciofluvial sediments comprise 6% of the study area and are concentrated within the major valleys. They are typically moderately sorted, weak to moderately compacted, cobble or boulder gravel with a sand matrix. These sediments are found in a succession of well-defined terraces ranging in height from a metre above the current river level to 70 m high. The gravel that occurs at the surface of the terraces is up to 5 m thick. At some locations, glaciofluvial gravel is found at higher elevations on valley sides in the form of hummocky blankets up to 10 m thick. Also found within valleys are glaciofluvial fans that are composed of sediments similar to those in the terraces, but are sandier. In upland regions, glaciofluvial sediment is dominantly sandy, pebble gravel that occurs in isolated areas, associated with meltwater channels.

The remaining 8% of the region consists of minor amounts of glaciolacustrine sediment, organic material (i.e., fens and bogs), colluvium, modern fluvial deposits and anthropogenically disturbed stratum. It is important to note that though glaciolacustrine sediment only covers a very small percentage of the surface (<1%), it underlies virtually all terraces found within the major valleys.

STRATIGRAPHY

The stratigraphy of unconsolidated sediments is summarized based on observations made during fieldwork, as well from previous studies (e.g. Clague et al. 1990, Clague 1991, Levson and Giles 1993). Two stratigraphic columns are provided that illustrate the succession of units described herein (see accompanying columns

Universal Transverse Mercator Grid Zone 10 North American Datum 83

> Fluvial gravel: This unit is present at the base of the Bullion Pit (unit a). Most often the unit is found unconformably overlying bedrock and are typically: strongly cemented, well stratified, well imbricated and well rounded (Levson and Giles 1993). These sediments were commonly sought after by placer miners during the past several decades. (F)

Pre-Late Wisconsin

Penultimate till: This is the oldest till in the region. It is a very well-compacted, clayey, silt diamicton containing 25% to 35% clasts. Clasts are subrounded to angular and range up to boulder in size. Clasts are commonly faceted and striated. It is interpreted as belonging to the penultimate glaciation and has been

described at only two locations in the study area, at the Bullion Pit (unit b) and at section AJB02-S12. (M)

Recessional ice contact and glaciofluvial: Sediments of these types are sandy gravel interbedded with medium to coarse sand and diamicton at its base. Generally, they exhibit crude stratification and imbrication with intertonguing lithologies and deformation structures. Clasts are subrounded to angular and range up to boulder in size. These sediments were laid subaqueously in close proximity to receding glaciers. More typical fluvial characteristics increase up-stratigraphy. These units (unit c and d) are found directly overlying penultimate till at the Bullion Pit and at section AJB02-S12. (F^G)

Interglacial sediment: The only known location of interglacial sediment within the study area occurs at the Bullion Pit (unit e) and is described and dated by Clague et al. (1990). It consists of interbedded peat and organic-rich silt, sand and gravel. Radiocarbon dates obtained from woody debris range from $46\,300\pm1740$ to $36\,840 \pm 430$ years before present. (L)

Late Wisconsin

Advance glaciolacustrine: This unit is the most extensive unit found in the major valleys and can be more than 100 m thick. It is characterized by sub-horizontal, rhythmically bedded sand, silt and clay in a coarsening upwards sequence (AJB01-L9, unit A; Bullion Pit, unit f). In places, the sediments are coarser, composed of interbedded gravel, sand and silt. This is particularly true for the Cariboo River valley. In a complete sequence, the upper, coarser beds become more steeply dipping and resemble foreset beds of a deltaic environment. The unit is often capped by fine-grained sediment, either rhythmically bedded or massive clay or silt (AJB01-L9, unit B; Bullion Pit, unit g). Near the upper surface of the silt or clay cap, dropstones are commonly found. (L^{G})

Fraser till: The youngest till is well-compacted, silty, clay diamicton that may contain small, amorphous pockets of sand (AJB01-L9, unit D; Bullion Pit, unit h). It typically consists of 30% to 35% clasts. The clasts range up to large boulder in size, are subrounded to angular in shape and are commonly faceted and striated. Where it conformably overlies glaciolacustrine sediment, it may contain intertonguing, poorly sorted, gravel lenses and have a sandier matrix (AJB01-L9, unit C). (M)

Recessional glaciofluvial: In the most complete sections, steeply dipping gravel overlies till (AJB01-L9, unit E). In general, the sections are well bedded, moderately sorted, pebble, cobble gravel with a coarse sand matrix. Locally, the gravel may have an open framework and be clast supported. Clasts range from subrounded to subangular in shape. (F^G)

Holocene

Fluvial/glaciofluvial gravel: Older sediments were eroded by river systems fed by receding glaciers and have formed a series of successively lower glaciofluvial terraces within the valleys. The highest, most well defined terraces occur approximately 70 m above the current river level. These terraces are composed of moderately to poorly sorted cobble gravel with a sand matrix. Clasts are typically rounded to subangular and range in size to large boulder. Imbrication consistent with the modern drainage direction is commonly found within these

Other modern sediments: The most recent deposits in the region include organic, fluvial and colluvial sediments. Organic deposits are found primarily in fens and bogs; fluvial sediment alongside active drainage courses; and colluvium on steep valley slopes or valley bottoms where mass wasting processes have transported

QUATERNARY HISTORY

The stratigraphic record and surficial geology of the study area is primarily the product of the Fraser Glaciation and associated depositional environments. Subordinate amounts of older sediment exist but are rare or occur below the current river level and are not exposed. Till and ice-contact sediment record the presence of glaciers and possible inundation of the Quesnel River valley prior to the late Wisconsin, > 59 ka BP(Clague 1992), during the climax and onset of deglaciation.

After glaciers had completely receded, a period lasting at least several thousand years of warmer, ice-free climate ensued (Clague et al. 1990). This period is known as the Olympic Interstade. During this time, the ancestral Quesnel and Cariboo River valleys became incised to a similar level as found today (Clague 1991).

By the Late Wisconsin, the climate had once again cooled and glaciers began to expand from the highlands, such as the Cariboo Mountains to the east, where they had previously been confined. This was the start of the Fraser Glaciation. Drainage in the major valleys became obstructed by outwash sediments, advancing glacial ice, or some other mechanism.

The inundated valleys acted as sediment traps for sediment shed from advancing glaciers, filling the valley to at least 730 m asl (ca. 100 m above current river level). As glaciers approached, the sediment deposited in the lake(s) became coarser. At some point the lake(s) became over-deepened, shortly before glaciers advanced throughout the region.

Glacial flow during the peak of the Fraser Glaciation is recorded by the abundant subglacial bedforms found throughout the study area, though less common in the northeast corner. Drumlinoid ridges, flutings and striae show a northwest-southeast orientation of ice flow whereas drumlins and craig and tails indicate flow to the

Deglaciation likely occurred as suggested by Fulton (1991) with alpine areas initially becoming free of ice and subsequently leaving detached, stagnating ice at lower elevations. As ice down-wasted, meltwater channels formed along ice margins, many of which can be seen on the plateaus. The presence of a large meltwater channel that connects the Cariboo River to Quesnel Lake, near the town of Likely, may be an indication that the lower reach of the Cariboo River valley was obstructed by ice or valley fill.

Evidence for recessional phase lakes and fluvial systems is scattered about the plateaus, though concentrated along the main drainage courses. As the drainage system became more well established, it began to erode through valley fill sediment, creating the succession of glaciofluvial terraces found in the major valleys.

Throughout the Holocene, denudation continued and eventually established the current drainage system.

ACKNOWLEDGMENTS

Funding and logistical support for field checks of terrain polygons was provided by the British Columbia Geological Survey Branch. Fieldwork was carried out with the assistance of Adrian Hickin, Hart Bichler, Paul Grant and Roger Paulen. In addition, mapping and stratigraphy has benefited from the technical advice of Victor Levson and John Clague.

 $46,300 \pm 940$

REFERENCES Bichler, A.J. 2003. Landslides, stratigraphy and surficial geology of the Hydraulic map sheet (NTS 93A/12). University of Victoria, Victoria.

British Columbia Resources Inventory Committee, 1996. Guidelines and standards for terrain mapping in

British Columbia, British Columbia Ministry of Forests, Victoria.

Clague, J.J., 1991. Quaternary stratigraphy and history of Quesnel and Cariboo river valleys, British Columbia:

implications for placer gold exploration. Current Research, Part A(Geological Survey of Canada, Paper

Clague, J.J., Hebda, R.J. and Mathewes, R.W., 1990. Stratigraphy and paleoecology of Pleistocene interstadial sediments, central British Columbia. Quaternary Research, 34: 208-226.

Fulton, R.J., 1991. A conceptional model for growth and decay of the Cordileran Ice Sheet. Geographie physique et Quaternaire, 45(No. 3): 281-286.

Holland, S., 1976. Landforms of British Columbia, a physiographic outline, Bulletin 48. B.C. Ministry of Energy, Mines and Petroleum Resources, 138 pp.

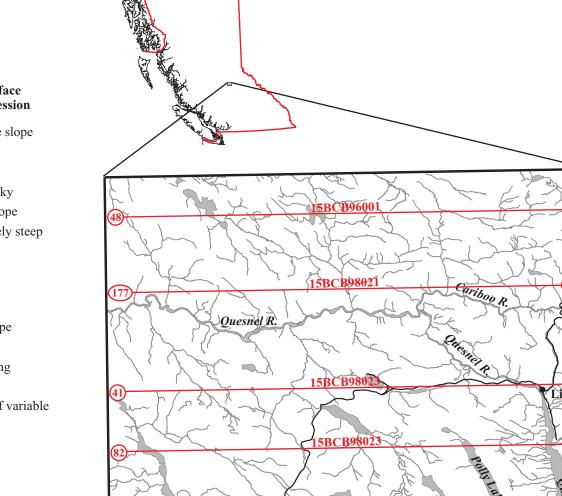
Howes, D.E. and Kenk, E., 1997. Terrain classification system for British Columbia. Version 2, British Columbia Ministry of Environment, Lands and Parks, Victoria.

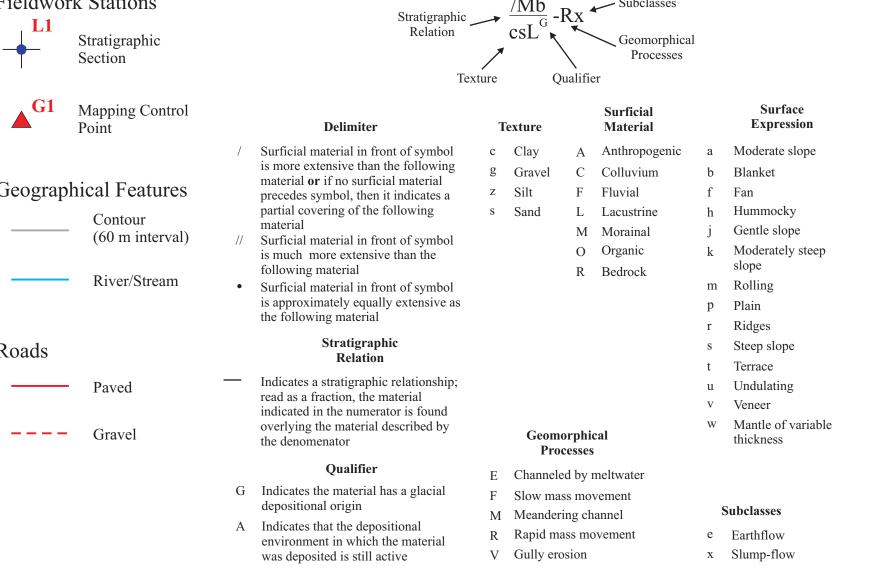
Levson, V.M. and Giles, T.R., 1993. Geology of Tertiary and Quaternary gold-bearing placers in the Cariboo region, British Columbia (93A, B, G, H), British Columbia Ministry of Energy and Mines, Victoria.

Meidinger, D. and Pojar, J., 1991. Ecosystems of British Columbia. no. 6, B.C. Ministry of Forests.

RECOMMENDED CITATION

Bichler, A.J. and Bobrowsky, P.T., 2003. Quaternary geology of the Hydraulic map sheet (NTS 93/A12), British Columbia. British Columbia Geosciences, Research and Development Branch, Open File 2003-7, scale 1:50 000.





(Modified from Howes and Kenk 1997)

