DRIFT EXPLORATION AND SURFICIAL GEOLOGY OF THE CLUSKO RIVER AND TOIL MOUNTAIN MAP SHEETS (93C/9, 16)

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INTRODUCTION

This report describes the details of field investigations carried out during 1:50 000-scale mapping of surficial geology on NTS map sheets 93C/9 and 16 (Figure 4-11-1). The area has good mineral potential but exploration is hindered in many areas by a thick cover of surficial sediment (Tipper, 1971). Surficial geology maps at a scale of 1:50 000 are available for the areas directly north and east of these map sheets but none exist for the current study area. The aim of this project is to provide 1:50 000-scale maps and surficial geology interpretation that will assist mineral exploration. Map products will be of two types: a terrain map, and a surficial exploration potential map. These maps and an accompanying report will be published separately. The project is funded by the Canada - British Columbia Mineral Development Agreement 1991-1995.

The only prior surficial geology map published for the area was based on fieldwork during the 1950s and 1960s conducted mainly for the purpose of mapping bedrock (Tipper, 1971). The map was published at a scale of 1:250 000 and described mainly surficial geology features, but not materials. Tipper's study was conducted prior to logging in the area and so could not take advantage of the many road exposures of surficial material now available.

Tipper interpreted an early, generally northward, glacial flow through the study area, which he equated with the Fraser glaciation of the Cordilleran ice sheet. Later eastward and northeastward ice flow in the western part of the area was interpreted as readvances by Fraser ice. As ice thinned during deglaciation, topography had an increasing effect on ice-flow direction, causing deflections around topographically high areas. Tipper described abundant sand and gravel deposits present in eskers and meltwater channels, that he suggested developed from a stagnant ice mass during deglaciation. He also mapped the approximate limit of re-advancing ice based on the position of "pitted terrain", and the different directions of ice-flow indicators on either side of this terrain. This feature transects the western part of the map area.

PHYSIOGRAPHY AND ACCESS

The study area is located on the Interior Plateau (Mathews, 1986) of British Columbia. It consists of several broad valleys that dissect the plateau, and the intervening high areas. Elevations range from about 1065 metres in the Clusko River valley at the southern boundary of 92C/9 to as high as 1770 metres above sea level at a hilltop southwest of North Hill (Figure 4-11-1). Most of the area lies between about 1220 and 1525 metres elevation.

Access to most of NTS 93C/9 is by Highway 39 west of Williams Lake to 100 Road which runs north from the highway on the east side of the bridge over the Chilcotin River at Redstone. The 100 Road follows the Clusko River Valley north of Chezacut, intersecting the southern boundary of the map sheet at about Kilometre 52 and traversing the map sheet from the southeast to the northwest. The northern and eastern parts of the map area contain a number of secondary logging roads and tracks that are easily traversed by four-wheeled all-terrain vehicle (ATV). Several

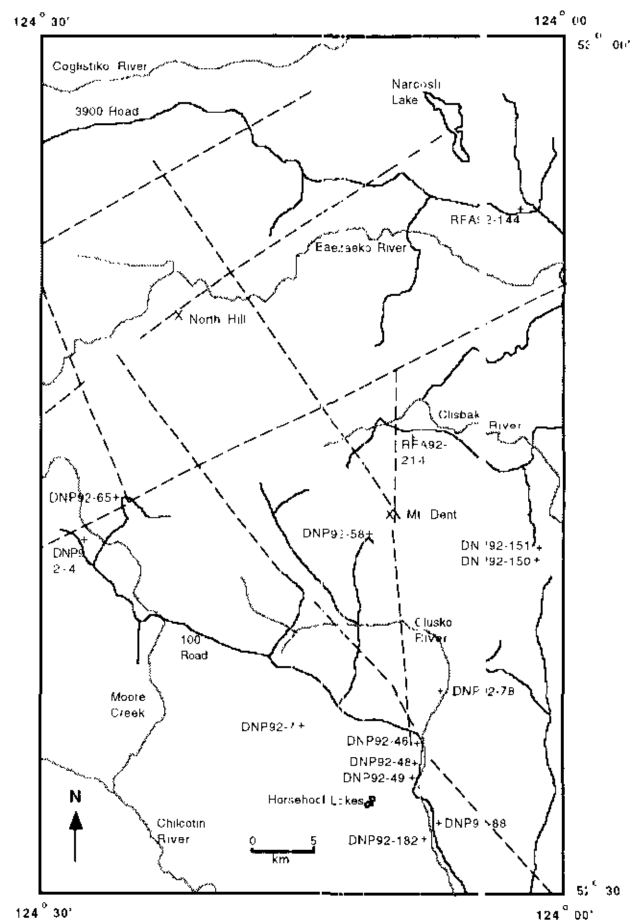

Figure 4-11-1. Location map of observation sites (+) and geographic names mentioned in the text. Dashed lines are seismic lines, solid lines are roads and grey lines are rivers.

seismic lines in the northern part of the map area were also traversed using ATVs. The southwestern quadrant of the map sheet and other areas with no road access were surveyed by helicopter for one half day.

MAPPING AND SAMPLING

A preliminary surficial geology map was prepared using 1:63 000-scale black and white aerial photographs. This was then verified in the field using natural and man-made exposures and hand-dug pits. A total of 187 bulk till samples, 1 to 2 kilograms in weight, and 145 pebble samples, each containing 100 pebbles (2 to 4 cm in diameter) were taken. Most bedrock outcrops were also sampled. Where till occurs along roads, tracks and seismic lines, till samples were taken every 1 to 2 kilometres The interval between samples varied to take advantage of the best exposures or to verify changes in sediment type.

Sample depth varied according to the type and quality of exposure. For small road cuts (<2 m high) samples were taken near the base, generally at least 60 centimetres below the surface. For larger natural and man-made exposures samples were taken at least 1 metre below the surface and in most cases as close to the base as was possible. Where exposures were not available tree-throw pits were sought to gain easy access for sampling 50 to 75 centimetres below surface. Elsewhere pits were dug by hand to sample to at least 40 centimetres depth. About 75 per cent of all samples were taken from existing exposures. Detailed evaluations of the exposed stratigraphy and sedimentology were recorded at each sampling site. This involved the description of deposit type, internal units and beds, bed contacts, structures, texture, and clast content and shape.

RESULTS AND INTERPRETATIONS

ICE-FLOW HISTORY

Ice-flow directions were determined primarily from geomorphic terrain indicators such as flutings and drumlinoid ridges evident on aerial photographs, and also on two striated outcrops. Unfortunately bedrock in the area is so friable and easily weathered that striations are rarely preserved. The earliest ice-flow direction recorded in the area is determined from two striation sites and numerous streamlined ridges. At site DNP92-7 in the south-central part of 93C/9, southeast of Thunder Mountain, striations on a polished metavolcanic rock trend 024° (Plate 4-11-1). The direction of flow is confidently interpreted from miniature crag-and-tail features in the rock. This direction of flow agrees with the orientation of numerous flutings in bedrock observed on aerial photographs about 7 kilometres to the east and in a zone 8 to 15 kilometres to the northeast (Plate 4-11-2). At site DNP92-150, in the northeastern part of 93C/9, striations occur on a small area of bedrock beneath a compact till exposed in a roadcut. They also trend 020°. The interpretation of ice-flow direction is based on stoss-and-lee features on the outcrop. This trend is parallel to numerous flutings in the east half of 93C/9 and near the southeastern border of 93C/16. It is the same direction as determined from a few crag-and-tail ridges observed on aerial photographs southeast of Mount Sheringham in the southeast part of 93C/9.

A limited number of easterly trending flutings (about 080°) observed on aerial photographs in the southwest corner of 93C/9 are interpreted to be the result of a subsequent advance. They are parallel to numerous flutings several kilometres to the west on NTS 93C/10. It is unlikely that

Plate 4-11-1. Striations on a bedrock surface at site DNP92-7.

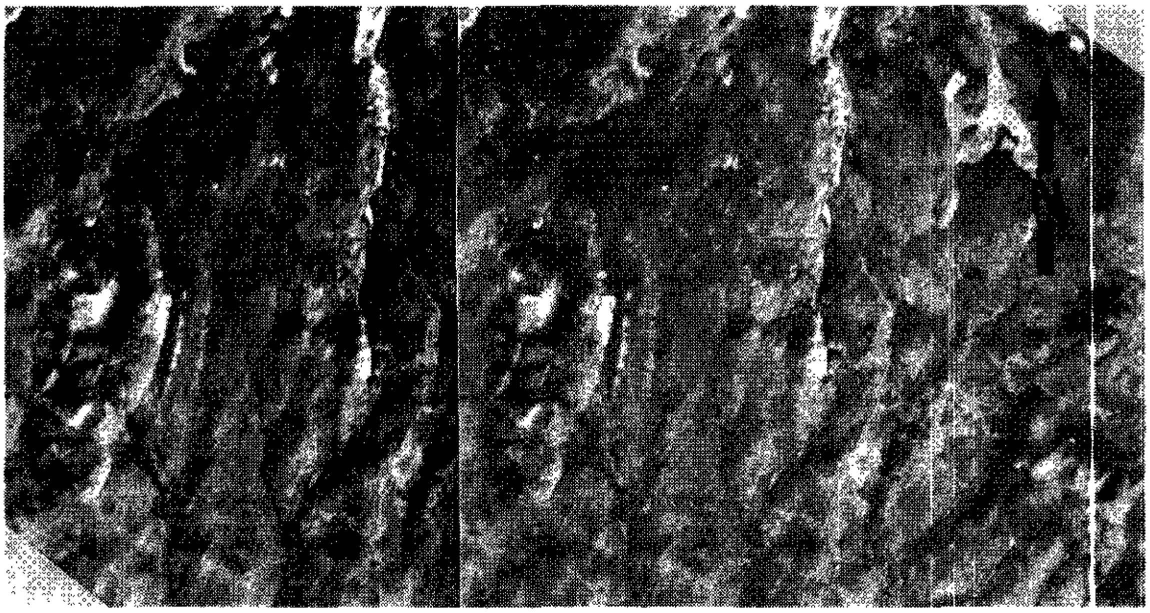

Plate 4-11-2. Photostereogram of north-northeast-trending glacial flutings on bedrock and till terrain southwest of Canyon Mountain (aerial photographs BC88041-206 and 207).

they were created at the same time as the north-northeastward flow that left flutings 17 kilometres to the east because the topography between them is not high enough to have caused deflection toward the northeast. Unfortunately the intervening area was subsequently eroded by subglacial and proglacial meltwater that would have removed this type of evidence. This second ice-flow direction is the same as Tipper's Fraser readvance.

There are also numerous northeast-oriented flutings in an area that extends northward from the north side of the Baezaeko River northwest of North Hill across the western third of 93C/16 to within 3 kilometres of the Coglistiko River. In the southern part of this area the flutings trend about 040° to 045° and gradually vere to 065° in the north. This gradual change in trend is probably due to topographic control of a relatively thin ice sheet as it deflected around the high area that includes a number of hills rising to above 1675 metres elevation.

A 500-metre band of short southeast trending low ridges that are tens of metres wide and about 100 to 200 metres long extends northwest from the northwest side of Narcosli Lake to beyond the northern boundary of the map sheet. They are only evident on aerial photographs. These ridges are most likely transverse moraines that formed perpendicular to northeastward flow. This feature transects a major northeast-trending esker system. The eskers must have been active during the ice flow that created the morainal feature.

There is no evidence in the map area from which to determine the relationship between the two areas of northeastward ice flow.

Surficial Sediments

This is a general description of surficial sediments observed in the map area. Greater detail will be provided with the maps.

TILL DEPOSITS

The term 'till' refers to diamicton of glacial origin and should not be confused with till-like diamicton that occurs as colluvium on many steep slopes or as debris-flow deposits in glaciolacustrine sediments. Till occurs on the surface in more than half of the map area and in most topographic settings, but is rare in valley floors. The geomorphology of areas of till cover varies from featureless to fluted or hummocky. Till generally has a silty sandy texture. Clasts are typically subangular to subrounded, range in size from small pebbles to boulders and form from 5 to 25 per cent of the volume of the till. Where till forms a veneer over friable or fractured bedrock, clasts are commonly more angular and comprise a much higher volume (up to 90%) of the sediment. Till deposit thickness ranges from less than a metre to several tens of metres. No multiple till sequences were found.

Where good till exposures occur in areas that are not hummocky, the sediment is generally massive, containing no lenses or beds of washed sediment. It is compact to very compact and in some places has a platy structure. This sediment is interpreted to have been deposited from the base of a moving glacier (Kruger, 1976).

Silty sandy till exposed in hummocks typically contains lenses or beds of sand and/or gravel or silt and is moderately to highly compact. This till is interpreted to have melted out from an englacial or supraglacial position within a glacier (Drewry, 1986). In some places, where sand and gravel deposits occur in close association with hummocky till, the till is low to moderately compact pebbly sand containing only minor silt. This sediment was probably also deposited from an englacial or supraglacial position. The coarser texture of the till may result if a larger proportion of sediment in transport was of glaciofluvial origin. At several sites (*e.g.*, DNP92-151) a veneer of clast-rich (>75% by volume) diamicton is dominated by angular cobbles (Plate 4-11-3). This sediment is interpreted to have been deposited from a supraglacial position.

A large area of hummocky moraine occurs in the northwestern part of the map area (Plate 4-11-4) and could have formed as part of the terminal moraine of eastward and northeastward ice flow during glacial readvance. Elsewhere, hummocky moraine is confined to small areas.

In a few valley settings, (*e.g.*, DNP92-58; Plate 4-11-5), thin beds of diamicton (5 to 20 cm thick) containing relatively few clasts (5% by volume) are interbedded with moderately to poorly sorted sandy gravel and laminated fine sand to silt beds. Contacts between these beds are sharp and drape underlying sediment. Laminations in silt-sand beds are commonly normally graded. This sequence was probably deposited in a glaciolacustrine environment relatively close to a source of meltwater. Sandy gravel and sand beds are probably high-density turbidity current deposits and sand and silt laminations are probably interflow deposits all of which emanated from a meltwater drainage system at the margin of the lake. The diamicton beds are interpreted as debris-flow deposits that slumped from valley walls and possibly a nearby glacier.

Sampling of tills was limited by the distribution of roads which tend to follow valleys that are almost all covered by

Plate 4-11-3. A veneer (80 cm thick) of cobbly sandy silty till containing about 80 per cent clasts overlying sandy silty till that contains about 15 per cent clasts most of which are pebble sized (DNP92-151). The pick is 90 centimetres long.

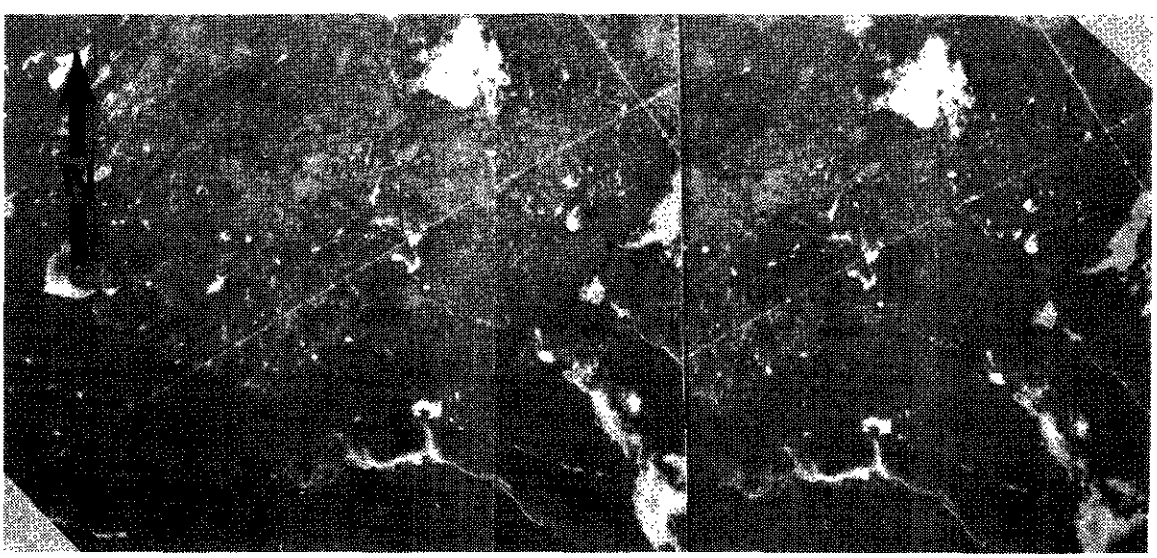

Plate 4-11-4. Photostereogram of hummocky moraine in the northwest corner of 93C/16 (aerial photographs BC88075-112 and 113).

Plate 4-11-5. Interbedded diamicton, sandy gravel and laminated fine sand and silt at site DNP92-58. The trowel is about 20 centimetres long.

Plate 4-11-6. A meltwater channel cut into sand and gravel and till at site DNP92-151. The channel is about 15 metres wide at the top.

sand and gravel. Geochemical analysis of bulk till samples and lithological analysis of pebble collections from most sample sites should help to clarify regional sediment dispersion by glacial transport.

SAND AND GRAVEL DEPOSITS

Sand and gravel deposits form a significant part of the surficial sediment cover in the area. They occur in two main settings: in most valleys, particularly tributaries to major river valleys; and in esker complexes that occur between and within valleys. Most eskers or esker complexes lead out of or into meltwater channels. In many places, particularly where underlying bedrock is basalt, these channels cut into bedrock. Where till is cut by channels, the channel floor is commonly covered with a cobbly lag deposit.

There are numerous steep sided valleys in the map area (Plate 4-11-6). Some are occupied by small modern streams, others have no flowing water in them. They are all meltwater channels eroded by subglacial and proglacial meltwater. Most of these meltwater channels contain terraces and blankets of sand and gravel that were deposited by flowing water with much higher energy than any of the modern rivers and streams in the map area. This sediment was probably deposited by glacial meltwater that was no longer confined by overlying ice.

Modern stream and river valleys also contain a significant volume of postglacial sand and fine gravel. Most of these deposits occur in channels and on the flood plain. The maximum grain size of these deposits is normally in the small pebble range, because of the considerably lower energy of the water flow.

Most eskers in the area are cobbly to pebbly sand and gravel that ranges from poorly to well sorted. Some are draped by a discontinuous veneer of till (Plate 4-11-7). Pebbles and cobbles are commonly subrounded to rounded. Thicknesses range up to about 15 metres but average 3 to 5 metres.

SAND AND SILT DEPOSITS

Sand and silt deposits cover less than 10 per cent of the surface in the map area. They occur in three settings: on the flood plains of modern drainage systems; as eroded remnants of glaciolacustrine valley fill in the Clusko and Clisbako River valleys; and as a veneer overlying till and glaciofluvial sand and gravel deposits. They are most significant in the Clusko River valley east and southeast of Horsehoof Lakes and in the headwaters of the Clusko River in the north-central part of NTS 93C/9.

The sediment on modern flood plains consists of interbedded fine to very fine sand and silt with minor clay, and occurs up to about 1.5 metres above present water level. Examples are well exposed along the Clusko River at site DNP92-78. Beds are discontinuous and vary in thickness up to 20 centimetres. Cut-and-fill structures and buried organic detritus are common. Here sediment was probably deposited by modern drainage during peak discharge periods and was derived from the winnowing of pre-existing glaciofluvial and glacial deposits.

Good exposures up to 8 metres thick of laminated fine to very fine sand, silt and clayey silt beds occur in several places (*e.g.*, DNP92-88, DNP92-65 and RFA92-144). At RFA92-144 (Plate 4-11-8) massive fine to very fine silty sand beds 5 to 10 centimetres thick are interbedded with laminated sequences of very fine sand, silt and silty clay. Laminations are normally graded and 0.1 to 5 centimetres thick. A few pebbles occur in this exposure. All of this sediment was probably deposited by medium to high-density turbidity currents in a glaciolacustrine lake.

In many valleys a discontinuous veneer of interbedded to laminated silt and sand and clayey silt overlies diamicton or sand and gravel deposits. At DNP92-46, a large esker is draped by less than 1 metre of laminated sand and silt similar to the sediment described in the previous paragraph. At DNP92-49, a 3-metre exposure of compact massive diamicton, interpreted as till, is covered by 2 metres of laminated clayey silt and very fine sand. This surface material is interpreted to be glacial lake sediment deposited after the glacier had retreated.

In Moore Creek valley in the northwest corner of 93C/9, glaciofluvial sand and gravel and rhythmically bedded glaciolacustrine sand, silt and clayey silt deposits are covered by a discontinuous veneer of massive to weakly laminated very fine sand and silt with no clay. In this area, at DNP92-4, a steep sided ridge, 8 metres high and composed of weakly laminated fine to very fine sand and silt, rests on a flat plain of diamicton that is interpreted to be till. This

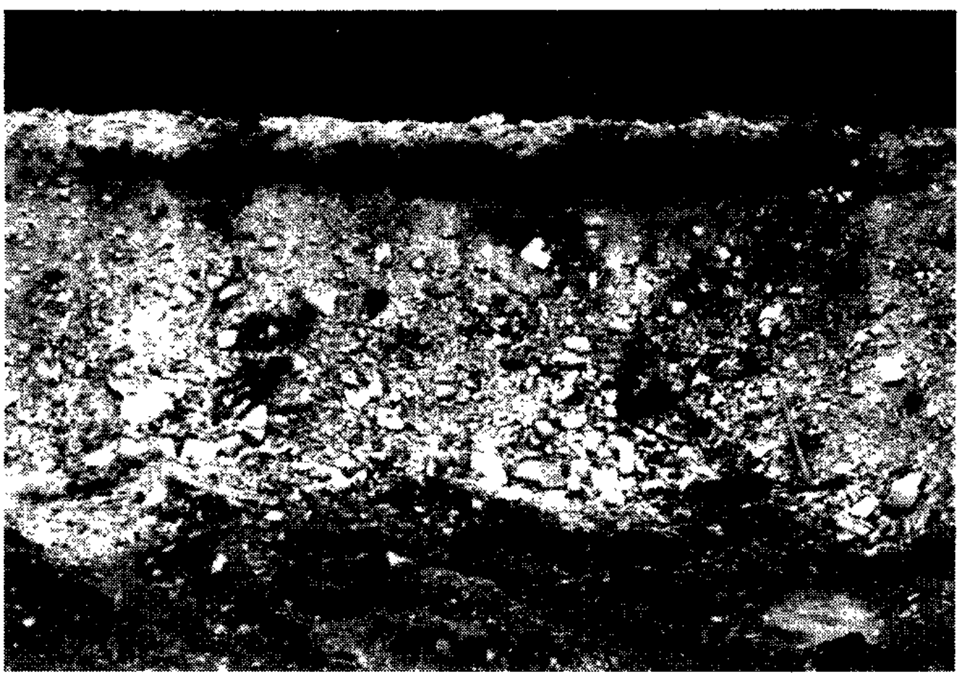

Plate 4-11-7. Glaciofluvial sand and gravel deposit overlying diamicton that is probably till. This is an example of a site in a broad area of sand and gravel where a reliable till sample could be taken (RFA92-214). The pick is 90 centimetres long.

Plate 4-11-8. Interbedded fine to very fine sand and silt at site RFA92-144. Silty beds are dark grey because of higher moisture content than surrounding sand.

ridge is probably a dune and similar sediment found as a veneer in the area is also interpreted to be eolian in origin. Unfortunately this area is heavily treed and appears featureless on aerial photographs. Small dunes less than 1.5 metres high were, however, observed on a grass-covered silty sandy fluvial plain, directly west of North Hill. All of this eolian sediment was probably derived from the surrounding glaciolacustrine, outwash and fluvial plains. Areas where diamicton is at the surface probably had the veneer of glaciolacustrine sediment removed by wind after the lake basin dried and before the establishment of vegetation. The veneer of glaciolacustrine and eolian sediment is underrepresented during mapping because of the difficulty in recognizing it on aerial photographs.

COLLUVIUM DEPOSITS

Numerous sites on or at the base of relatively steep hillsides contain a veneer of massive or thinly bedded diamicton (*e.g.*, DNP92-48). Bedding planes and the broad side of flat pebbles are parallel to the local slope. Cut-and-fill lenses and stringers of sand and gravel are also common. This sediment was deposited by slope processes that occurred mainly when there was no vegetation, either in early postglacial time or after forest fires.

ORGANIC SEDIMENT

Organic sediment consists of a mixture of silt, sand and decayed plant remains (mainly bog plants and grasses). It occurs in poorly drained depressions, especially in abandoned meltwater channels, along the edge of ponds and on modern flood plains. Away from modern drainage it consists mainly of black organic mud, however, along active drainage the mud contains abundant silt and sand.

QUATERNARY HISTORY

The history of deposition and erosion of surficial sediment in the area has been constructed from deposit and landform field relationships and sediment genesis. There have been at least four glacial events recorded in this part of British Columbia (Fulton, 1984). In the absence of good multiple till exposures and dateable organic material, the simplest stratigraphic interpretation is used. These Quaternary geologic events are summarized below:

(1) Deposition of proglacial sand and gravel during glacial advance. Fluvial sediment deposited during erosion of the area in late preglacial time would have been reworked during and after glaciation and has not been recognized.

(2) Deposition of a till blanket or veneer by actively flowing ice during glaciation.

(3) Deposition of hummocky moraine during glacial retreat or stagnation. Contemporaneous development of meltwater channels beneath and beyond glacier ice. Major pre-existing valleys would have been drainage conduits.

(4) Ponding of meltwater behind ice dams and ice-cored moraines that blocked drainage. This resulted in the formation of relatively short-lived lakes along which deltas formed (DNP92-182) and finer sediment was deposited.

(5) Drainage of glaciolacustrine lakes and re-establishment of regional drainage. Erosion of glaciolacustrine sediment by postglacial drainage.

(6) Glacial readvance into the western margin of map area. Deposition of hummocky moraine along the ice margin?

(7) Disintegration of readvance ice. Enhancement of drainage to east and northeast from this ice. Further deposition of sand and gravel in meltwater channels.
(8) Drying out of lake basins and outwash plains. Reworking of fine sediment by wind.
(9) Establishment of modern drainage, bogs and colluviation of hillsides.

IMPLICATIONS FOR MINERAL EXPLORATION

There are three major problems for drift exploration in the study area; first the problem of basal-till sampling. There are large areas that contain little or no basal till at the surface. In glaciated terrain, basal till is the most desirable sediment to sample because it is normally the shortest travelled of glacial sediment types and can be most easily traced to its source.

The sediment in hummocky terrain was probably deposited from debris well above the base of the glacier. This material is presumed to have travelled farther than basally derived till. The deposition of hummocky terrain occurs during melting and therefore has abundant meltwater associated with it. In the study area this meltwater has cut numerous channels (Plate 4-11-6) many of which expose till of probable basal origin. Detailed drift-sampling programs should therefore be devised to sample carefully along these channels. The resulting sample distribution would likely be less systematic but far more useful. In the absence of meltwater channels, samples should be taken between hummocks to a depth of at least metre. This will be much more time consuming than typical sampling programs and will provide less samples for the same cost, but the results should be more effective.

Secondly, what to do in a sampling program where till is scarce? Anomalies in glaciofluvial and fluvial deposits potentially have had a more complex history of transport from bedrock source to final deposition. They may have been derived from till or sand and gravel deposits and are thus at least a second derivative from their source (Shilts, 1975). In most of the study area till underlies or is adjacent to sand and gravel and glaciolacustrine deposits. However because roads follow valleys and outwash, due to the presence of sand and gravel, the only exposures are of sand and gravel. Sampling programs should be offset to adjacent till-covered terrain where possible. The map area is anomalous because of the abundance of meltwater channels. In some areas of sand and gravel cover, till is exposed in the side of the channels.

Finally, bedrock striation sites are rare and large-scale glacial-flow features only occur in a few places. These data have allowed for an interpretation of regional ice flow, however local variations due to topographic influences cannot be determined. Numerous detailed till-fabric measurements must be carried out to determine local flow directions.

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