SURFICIAL GEOLOGY AND DRIFT EXPLORATION STUDIES IN THE FAWNIE CREEK AREA (93/F3).

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KEYWORDS: Surficial geology, drift exploration, till, glaciofluvial outwash, glaciolacustrine sediments, applied geochemistry, mineral dispersion, dispersal trains.

INTRODUCTION

This paper describes the preliminary results of surficial geological mapping and till geochemistry sampling during the 1993 field season in the Fawnie Creek (93F/3) map area (Figure 1). This work is part of a larger program in the Interior Plateau that includes bedrock mapping, lake geochemistry and mineral deposit studies (*see* Diakow and Webster, Cook and Jackaman, and Schroeter and Lane, respectively, 1994, this volume). The program is designed to test the applicability of surficial geology data to drift prospecting in regions where mineral exploration has been hampered by thick drift cover. Neogene lava flows, an outdated geological database and a lack of modern geochemical and geophysical information have also hindered exploration in the area. Surficial geological mapping in the area was completed in order to understand the glacial history and provide a basis for design of a till geochemical sampling program. The projects main goals, designed to address these problems, are:

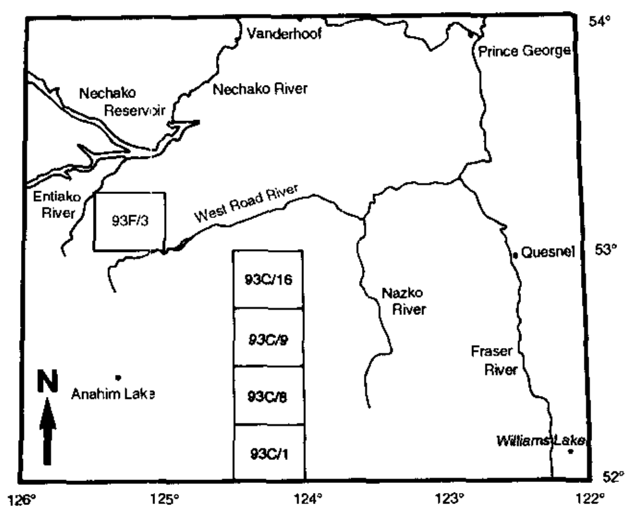

Figure 1. Location map of the Fawnie Creek (93F/3) map sheet. The 1992 study areas Chilanko Forks, Chezacut, Clusko River and Toil Mountain (93C/1, 8, 9, 16 respectively) are also shown (Giles and Kerr, 1993; Proudfoot, 1993).

- to compile a 1:50 000 surficial geology map of the Fawnie Creek area (93F/3), conduct stratigraphic and sedimentologic studies of Quaternary deposits in the area, and define the glacial history and ice-flow patterns;

- to complete a regional (1:50 000) till sampling program and produce a series of till geochemistry and drift exploration potential maps for mineral exploration purposes; and

- to develop and refine methods of drift exploration applicable to the Interior Plateau region by conducting detailed case studies around known mineral deposits.

STUDY AREA

The Fawnie Creek map area lies within the Nechako Plateau, in the west-central part of the Interior Plateau (Holland 1976). The Fawnie Range dominates the northeast corner of the map area, reaching elevations of over 1775 metres (5800 feet; Figure 2). Entiako Spur extends across the northern half of the region, with elevations dropping westward from 1750 metres (5700

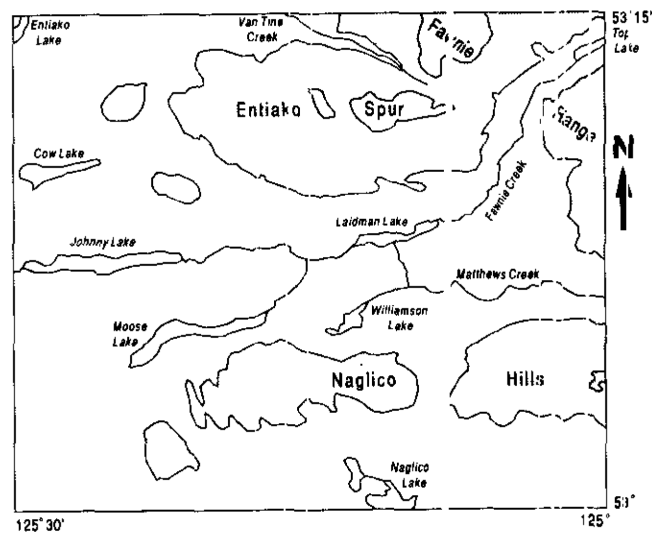

Figure 2. General physiography of the Fawnie Creek area. The light shading represents areas with elevations above 1200 metres (4000 feet) and the darker shading areas in excess of 1520 metres (5000 feet).

feet) to below 1200 metres (3900 feet). Fawnie Creek valley occupies the centre of the map area and flows from Top Lake at an elevation of around 1070 metres (3500 feet) southwest through Laidman and Johnny lakes. The Naglico Hills form the southern margin of the Fawnie Creek valley, reaching elevations of 1550 metres (5100 feet) in the east and 1370 metres (4500 feet) in the west and they, in turn, are bounded on the south by the valley of the Blackwater River. All valleys in the area are broad with gently inclined sides reflecting glacial modification, except Van Tine Creek (Figure 2) which is perpendicular to ice flow and has a sharp V-shaped valley.

During the last or Late Wisconsinan glaciation, ice moved into the Fawnie Creek map area from the Coast Mountains before flowing north, northeast and east onto the Interior Plateau (Tipper, 1971). Coast Mountain ice extended as far east as the Fraser River before coalescing with Cariboo Mountain ice flowing to the west and northwest.

The study area is approximately 150 kilometres from Vanderhoof and is accessed by the Kluskus-Ootsa Forest Service road. Logging road access within the north half and southeast quarter of the map area is good but much of the west and southwest are accessible only by trails.

METHODS

Surficial geology mapping was completed by interpretation of air photographs, field checking existing terrain map data (Tipper, 1954, 1963; Howes, 1976, 1977), and stratigraphic and sedimentologic studies of Quaternary exposures in the study area. Ice-flow history for the Fawnie Creek map area was largely deciphered from the study of crag-and-tail features, flutings and drumlins (Plates 1 to 3); striation measurements are also good local ice-flow indicators.

Till samples were collected for geochemical analysis in order to locate glacially dispersed mineralization present in the region. Regional sample locations were selected to obtain complete coverage of the map area, with the greatest density of samples along transects perpendicular to established ice-flow direction. In ice-parallel situations, where samples repeatedly represent the same terrain directly up-ice and therefore duplicate each other, wide-spaced sampling was used. An intermediate sample spacing was used on transects oblique to flow. Samples were collected from the C

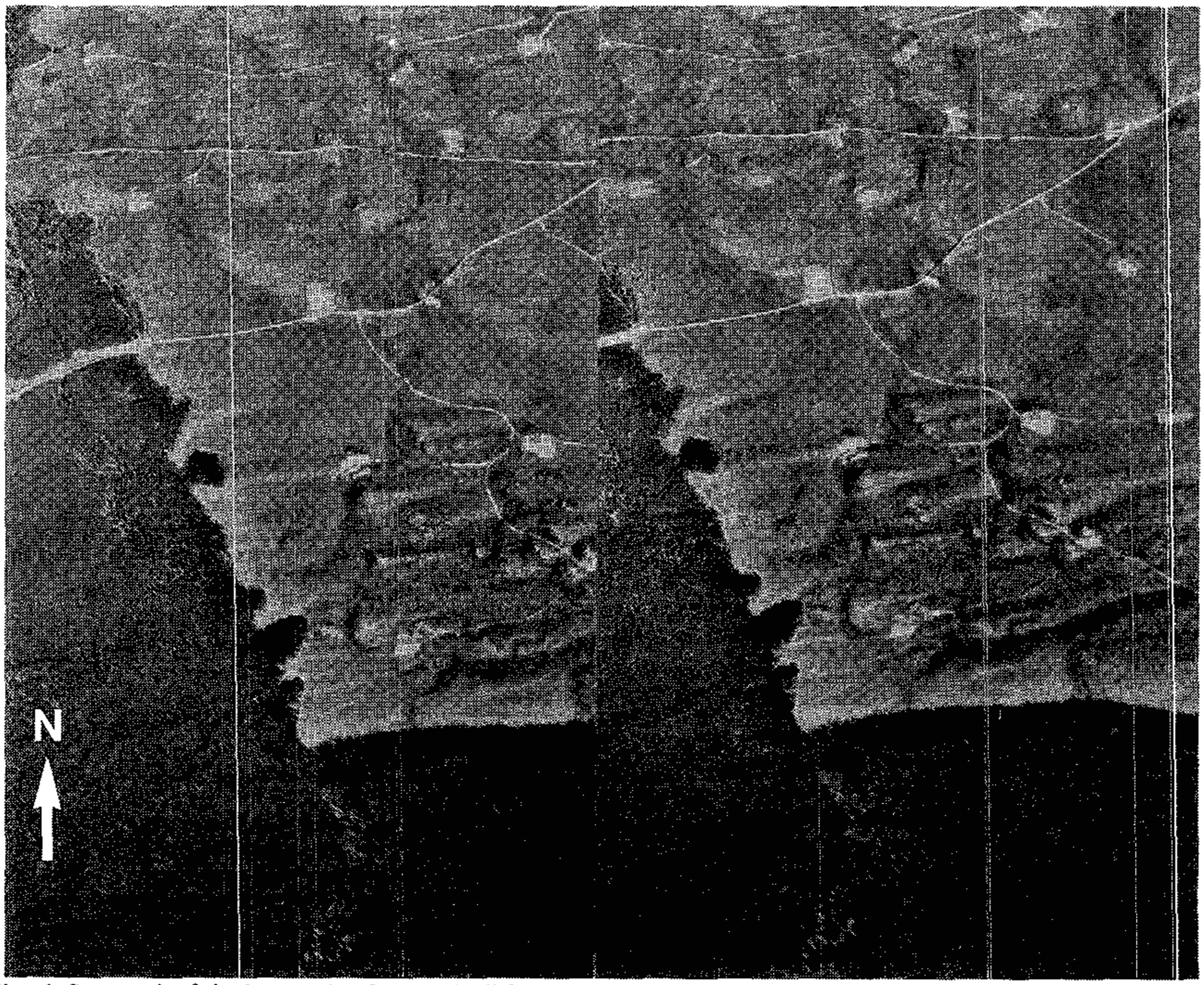

Plate 1. Stereo pair of air photographs of crag-and-tail features formed by glacial action on the north flank of the Naglico Hills near Williamson Lake. Note the consistent orientation of the linear tails toward the east in the down-ice flow direction. Note also how forest cover obscures glacial features in unlogged areas. Air photographs BCB 92048-68 and 69.

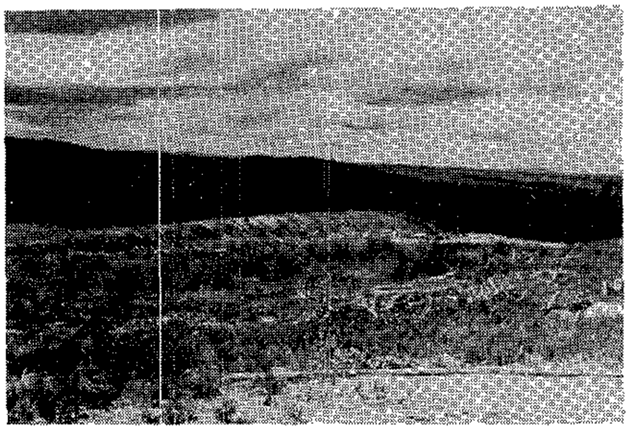

Plate 2: Crag-and-tail feature. A crag or knob of bedrock is exposed at the right (west) and the tail of sediment which filled the cavity beneath the ice is preserved to the left. Glacial ice-flow direction is from right to left (065°).

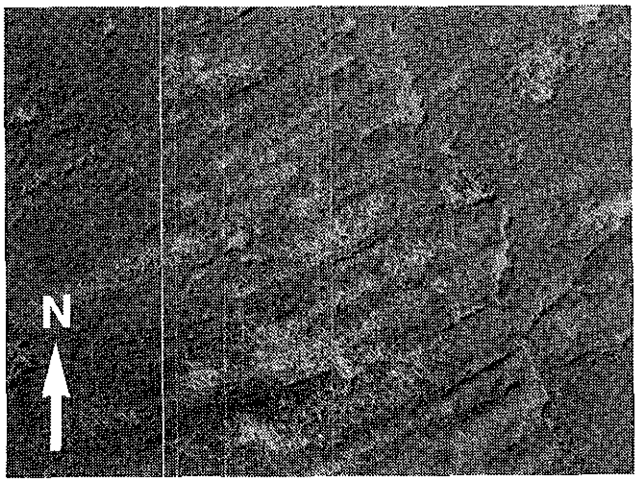

Plate 3: Air photograph of east-northeast oriented flutings reflecting regional ice-flow direction on the southwest side of Entiako Spur. Air photograph BCB 91087-160.

mineral soil horizon, which is comparatively unaffected by the pedogenic processes operative in the A and B soil horizons (Agriculture Canada Expert Committee on Soil Survey, 1987; Gleeson *et al.*, 1989). Sample sites consist of natural and man-made exposures (roadcuts, borrow pits, soil pits and trenches). Locations of samples sites were plotted on a 1:50 000 topographic base map with the aid of air photographs. A total of 229 till samples were collected throughout the study area (Figure 3) at a density of approximately one sample per 4 square kilometres. Higher density sampling was conducted in areas of perceived higher mineral potential and around known mineral prospects to provide a clearer understanding of glacial dispersion processes. At each sample site, data collected included descriptions of sediment type, primary and secondary structures, matrix texture, presence of fissility, compactness, total percentage and modal size of clasts, rounding of clasts, local slope, presence of striated clasts, and sediment genesis and thickness. Further information was noted on soil horizons, bedrock striae, bedrock lithology, clast provenance and abundance of mineralized erratics.

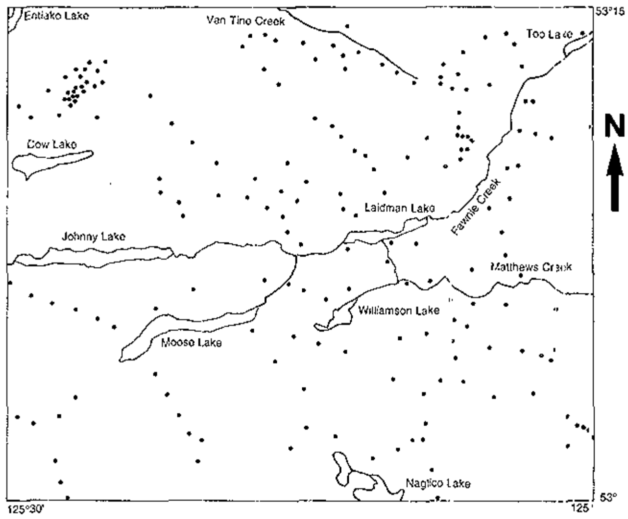

Figure 3: Location map of sample sites in the study area. The concentration of sites in the northwest corner reflects more detailed sampling completed in the vicinity of the Wolf prospect. Note the bias towards SE trending transects (perpendicular to regional ice-flow direction).

Detailed till and soil geochemistry sampling was conducted at three mineral prospects (Wolf, MINFILE 93F 045; Capoose, MINFILE 93F 039; and Blackwater-Davidson MINFILE 93F 037), two mineral showings (Fawn, MINFILE 93F 043; and Yellow Moose, no MINFILE) and two newly discovered prospects (no MINFILE; see Diakow and Webster, 1994) to document mineral (elemental and lithologic) dispersion processes (Table 1). Each site is unique in geomorphologic, sedimentologic or stratigraphic setting. Approximately 122 samples were collected along ice-parallel or ice-perpendicular, linear or fan-shaped traverses to document glacial dispersion and transport distance.

The most intensive survey was conducted at the Wolf epithermal gold-silver deposit. This included striation measurements to determine the local ice-flow history and a down-ice fan sampling program to gather information on mineral transport and dispersal. Samples were also taken up-ice from the prospect to determine background geochemical levels. Detailed sedimentologic and stratigraphic studies were conducted in numerous well-exposed trench sections in conjunction with a geochemical sampling program undertaken by University of British Columbia researchers (Delaney and Fletcher, in preparation). A steeply sloping trench with known bedrock geochemical values on the east side of the property was sampled in detail to document downslope dispersion in colluvial sediments.

Till samples were dried, split and sieved into three size fractions: 70 to 140 mesh (105 to 210 µm), 140 to 230 mesh (62.5 to 105 µm), and less than 230 mesh (less than 62.5 µm). All the -230 mesh fractions were analysed by instrumental neutron activation analysis (INAA) and inductively coupled plasma analysis (ICP) for 32 elements. The two coarser (105 to 210 µm and 62.5 to 105 µm) fractions of samples taken during the detailed case studies, as well as several random samples from the

TABLE 1: DISPERSION STUDIES

Location	Deposit Type	Purpose	Samples	Sampling Design
Wolf	Epithermal Au-Ag	Glacial dispersion	40	Down-ice fan traverse
		Down-slope dispersion	24	Slope profile traverse
Mount Davidson	Transitional Au-Ag	Glacial dispersion	3	Linear down-ice traverse
Yellow Moose	High-level epithermal Hg-Au-Ag	Glacial dispersion	16	Down-ice fan traverse
Capoose	Transitional Au-Ag	Glacial dispersion	8	Linear down-ice traverse
Fawn	Epithermal Au-Ag	Glacial dispersion	12	Ice-flow perpendicular traverse
New discovery A	Unknown	Document lateral extent of deposit	11	Ice-flow perpendicular traverse
New discovery B	Unknown	Document lateral extent of deposit	8	Ice-flow perpendicular traverse

regional survey, were also analysed to investigate if mineral dispersion is similar in all size fractions during transport. One half of the sample splits was reserved for grain size and other follow-up analyses.

Approximately 100 pebbles were collected at till sample sites for lithologic analysis and provenance studies. Results will be used to investigate the relationship between bedrock geology and till clast lithology, glacial dispersion, rates of clast abrasion and rounding, and distances of travel. These data will be useful for tracing mineralized float to its source and to help determine bedrock lithology where exposure is limited due to drift cover.

SURFICIAL GEOLOGY

MORAINAL SEDIMENTS

Morainal deposits include all sediments deposited directly by or from glaciers with little or no reworking by water (Dreimanis 1989). Morainal sediments of the last glaciation occur throughout the Fawnie Creek map area and include lodgement and melt-out tills as well as glacigenic debris-flow sediments. Surficial geology mapping in the area shows that morainal sediments are the most widespread Quaternary deposits. They form a cover of variable thickness across much of the area and may occur as hummocky, kettled, fluted or relatively flat topography. Till thickness varies from a few to several metres in low-lying areas to less than 2 metres in upland regions and along steep slopes. Exposures of till up to 8 metres thick were observed in valleys perpendicular to the regional ice-flow direction (Figure 4, Section 93-9, Van Tine Creek). Exposures of till 1 to 2 metres thick are common on bedrock highs (Figure 4, Sections 93-1, 93-7, 93-15). In Fawnie Creek and Matthews Creek valleys, morainal sediments are largely buried by glaciofluvial outwash, fluvial and organic sediments.

Two distinct facies of morainal sediments are recognized: a compact, fissile, matrix-supported, sandy silt diamicton and a loose, massive to stratified, sandy diamicton. (Diamictons are defined as poorly sorted deposits consisting of mud, sand and gravel.) The first is interpreted to be basal lodgement and melt-out till and the latter to be glacigenic debris-flows and resedimented deposits. Basal tills seldom occur at the surface, usually being overlain by glacigenic debris-flow deposits and, on slopes, by resedimented diamictons of colluvial origin.

Basal tills are moderately to well compacted but range from weakly consolidated to very compact or overconsolidated. Moderate to strong platy fissility exists in the majority of the samples (Plate 4), although they are occasionally weakly fissile or nonfissile. Vertical jointing is common and blocky structures occur where the sediment has been exposed to the sun and is relatively dry (Plate 5). Weak to very strong oxidation of the till, characterized by reddish brown staining, is common and can occur pervasively or along vertical joint planes and horizontal partings. Subhorizontal slickensided surfaces are sometimes present, especially in clay-rich till.

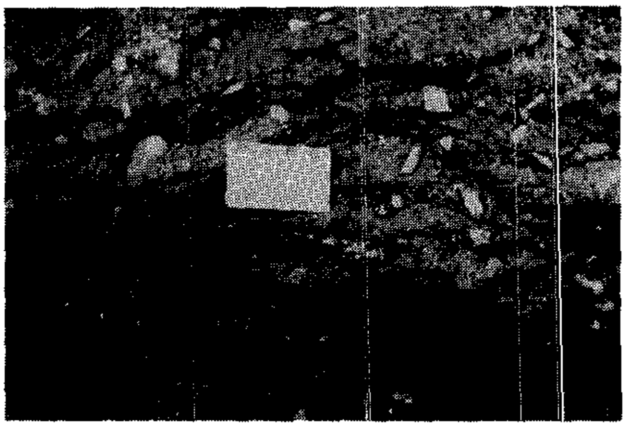

Plate 4: Subhorizontal partings in massive diamicton interpreted as lodgement till.

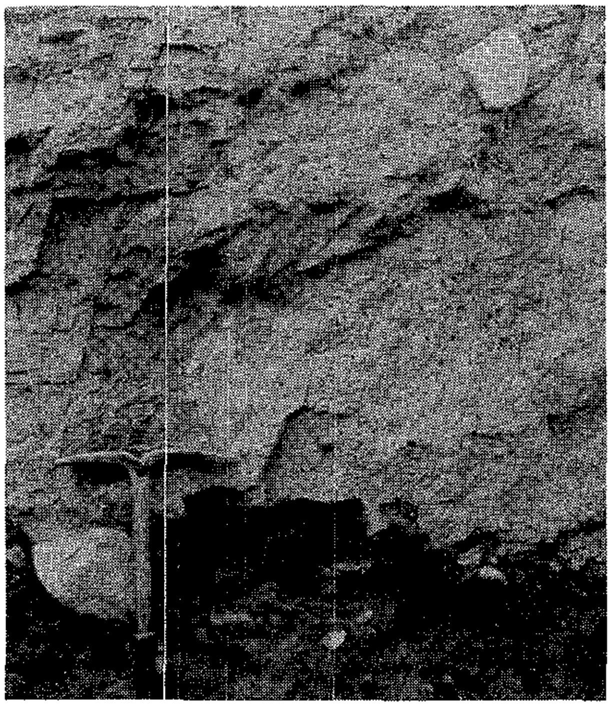

Plate 5: Melt-out till overlying proglacial outwash. Note the massive, resistant nature of the till.

Clasts in the basal tills range in size from small pebbles to large boulders with medium to large pebbles dominating most exposures. As much as 50% of the till may be comprised of clasts, but most exposures have between 10 and 30% clasts. Striated, faceted, embedded and lodged clasts are common and typically up to about 20% of the clasts are striated. Striated clasts are commonly flat lying and bullet shaped, and may be aligned parallel to ice-flow direction. Crude bedding locally visible in the tills, is indicated by higher percentages of small pebbles in some beds.

Lower contacts of basal till units vary from sharp and planar to gradational and irregular. Where till overlies competent bedrock that abraded slowly by sediment-rich basal ice, there is a clear and sharp contact. In some places, lower contacts are gradational with zones of broken, angular bedrock with little matrix, overlying fractured bedrock. Injections of till into bedrock fractures indicate high pressure conditions at the base of the ice during deposition. Occasionally, bedrock slabs have been lifted up into the body of the till; commonly they are folded and faulted but rarely are intact blocks preserved.

Diamictons of inferred debris-flow or colluvial origin (Plate 6) are loose to weakly compacted and are either massive or interbedded with stratified silt, sand or gravel. Clasts vary in size from small pebbles to large boulders but are usually medium to large pebbles. These diamictons typically contain 20 to 50% clasts although up to 70% are present locally. Subangular to subrounded clasts are most common, but local angular fragments dominate in some shallow exposures over bedrock. Up to 10% of the clasts are striated. Lenses and beds of sorted

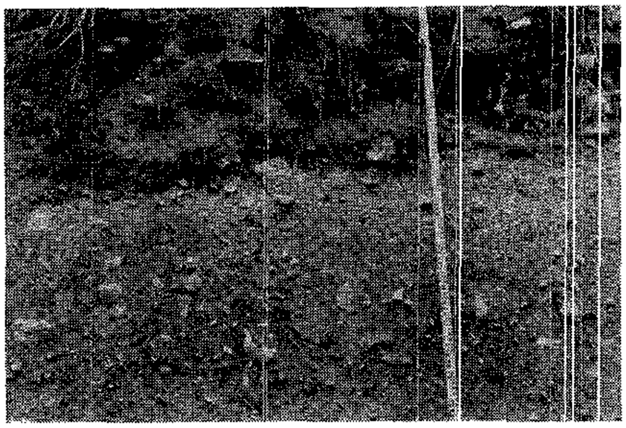

Plate 6: Loose, massive-appearing glacially-derived debris flow deposits overlain by sandy colluvium. Marked increments on measuring rod are labelled every 10 centimetres.

silt, sand and gravel occur in many exposures and may be continuous for up to 5 metres, although they are most frequently 10 to 100 centimetres wide. Debris-flow deposits may exhibit weak to very strong oxidization preferentially along the more permeable sand and gravel beds. Debris-flow units have gradational to clear lower contacts and typically overlie basal till.

GLACIOFLUVIAL SEDIMENTS

Glaciofluvial sediments are common in the map area and occur as eskers, kames, terraces, fans and outwash plains in valley bottoms and along valley flanks. They consist mainly of poorly to well-sorted, stratified, pebble and cobble gravels and sands in deposits up to 10 metres thick. Thick sequences of glaciofluvial sands and gravels occur in large valleys (Fawnie, Matthews and Van Tine) (Figure 4, Section 93-9, Van Tine). Clasts are rounded to well rounded, vary in size from small pebbles to cobbles with rare boulders.

In upland areas on Entiako Spur, Naglico Hills and the Fawnie Range, postglacial glaciofluvial sands and gravels occur as a veneer or thin blanket, up to 2 metres thick, on top of till (Figure 4, Section 93-15). Structureless or crudely bedded, small-pebble to cobble, sandy gravel beds are common. Clasts may be up to boulder size, are frequently striated and vary from rounded to angular. Many of these deposits are interbedded with gravelly diamictons indicating that they are proximal outwash deposits.

Advance phase glaciofluvial sediments were observed at one site on the south side of Entiako Spur under till within a bedrock channel cut oblique to ice flow (Figure 4, Section 93-7). Horizontally stratified medium to coarse sand beds at the base of the section are erosionally truncated by a poorly sorted, crudely imbricated, clast-supported cobble gravel. Clay intraclasts, up to 10 centimetres in diameter occur in the gravel. These sediments are interpreted as proglacial, proximal braided-stream deposits.

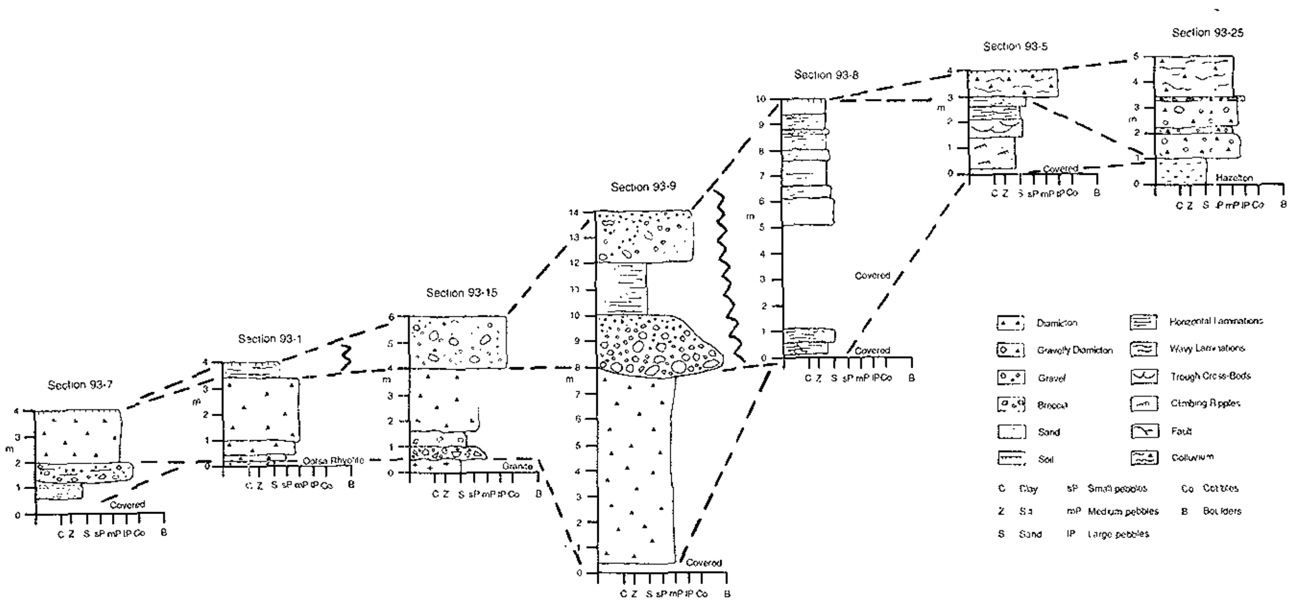

Figure 4. Representative stratigraphic columns of Quaternary deposits and interpretative correlation of main units in the study area.

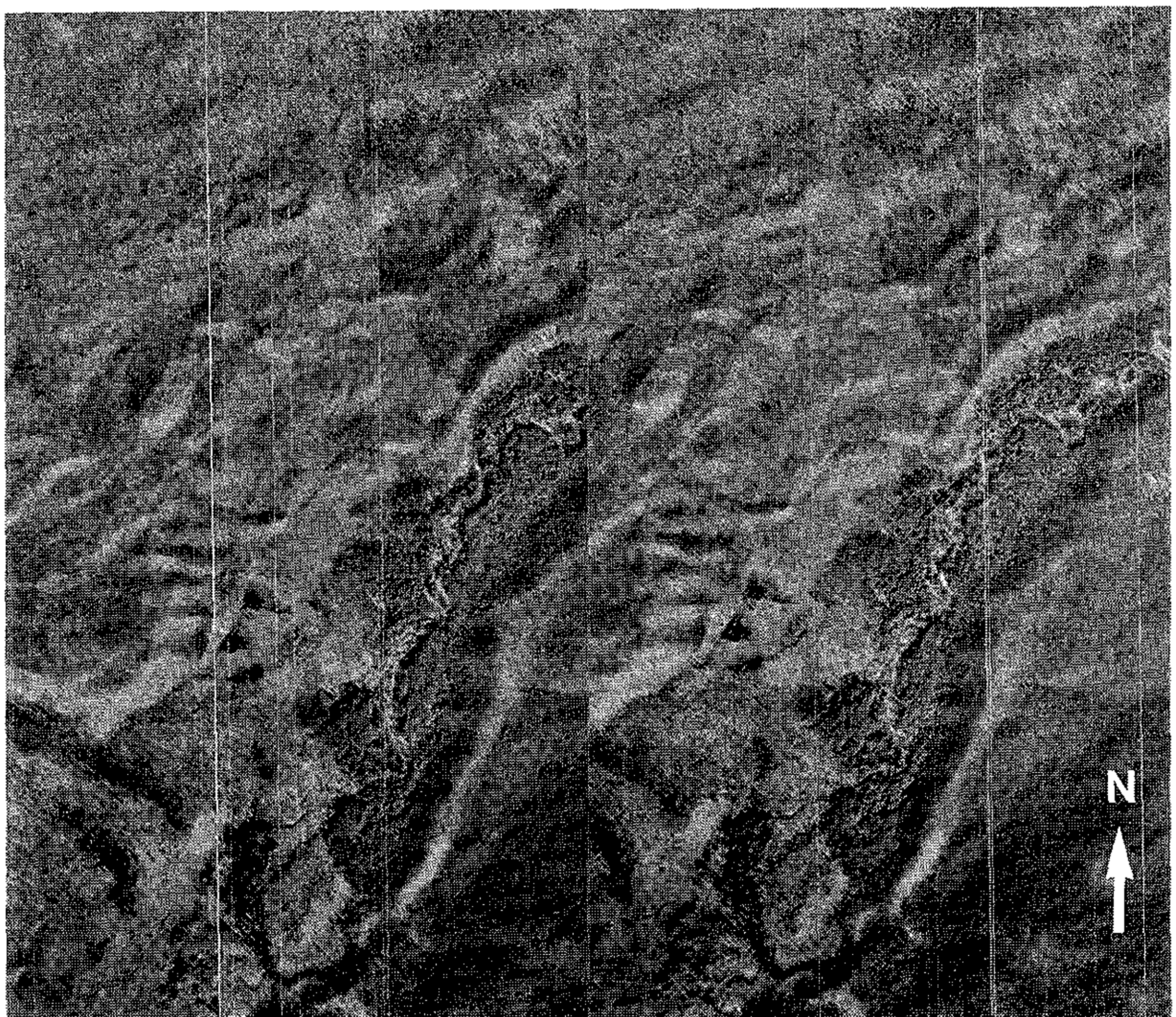

Plate 7: Stereo pair of the glaciofluvial complex southwest of Top Lake. Meltwater channels, gravel ridges and kettle depressions are visible. The incised, post-glacial Fawnie Creek valley extends from the right centre to the bottom centre of the plate. Air photographs BC 4281-153 and 154.

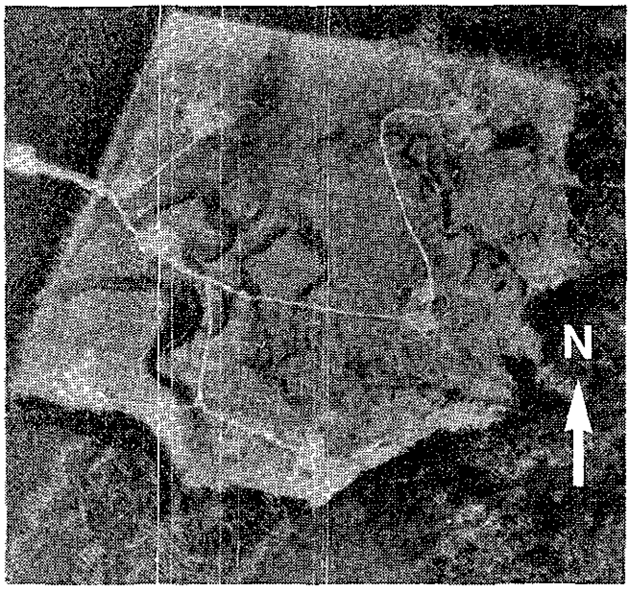

Plate 8: Meltwater channels developed near the margin of stagnating ice masses on the south side of the Entiako Spur. Air photograph BCB 91088-174.

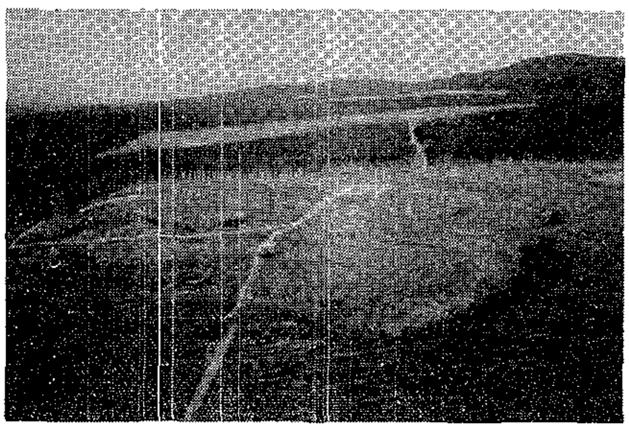

Plate 9: Oblique view, looking westerly, of meltwater channels seen in Plate 8.

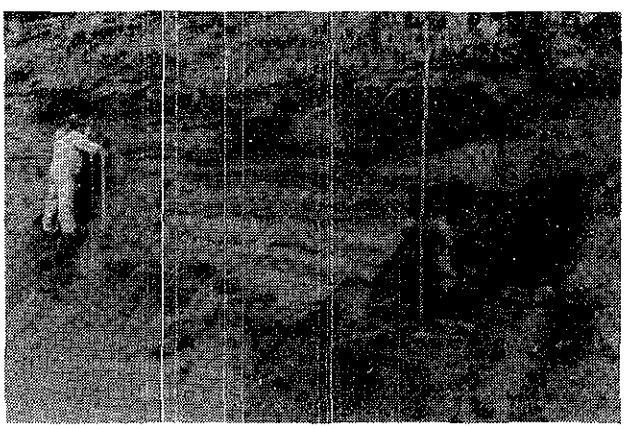

Plate 10: Well-sorted, ripple-bedded, fine to coarse sand in a coarsening upward sequence deposited in a small fan-delta on the south side of Entiako Spur.

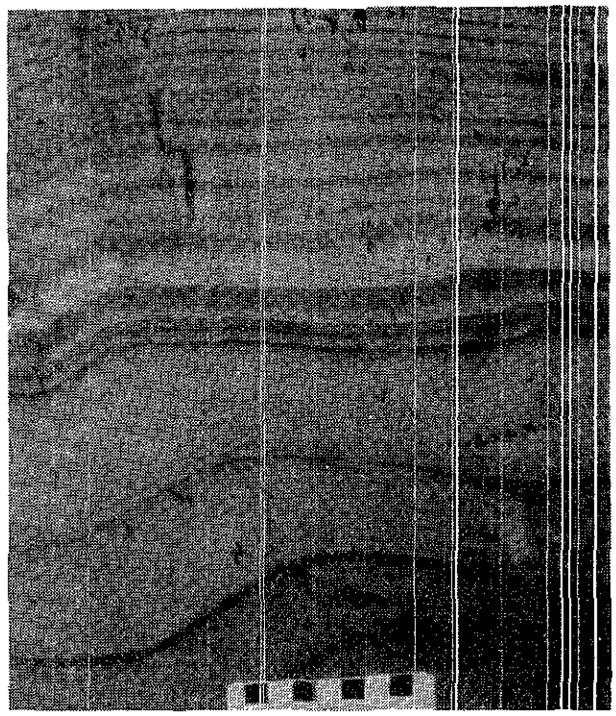

Plate 11: Depositional-stoss climbing ripples of the glaciolacustrine sand facies overlain by horizontally laminated fine sand, silt and clay. Scale is in centimetres.

Hummocky topography at the confluence of Van Tine and Fawnie valleys, consisting of ridges and knobs of sand and gravel with large kettles, indicates the presence of ice blocks within gravelly sediments during deposition of an outwash fan (Plate 7). On the southeast margin of Entiako Spur, large kame deposits and an extensive series of meltwater channels (Plates 8 and 9) developed parallel to the ice margin indicate prolonged ice stagnation and ablation. Moderately sorted, crudely bedded gravel and sand terraces high on the eastern margin of Fawnie valley are deposits of high-level ice-marginal channels formed during ice retreat or stagnation.

Approximately 20 kilometres to the northeast of the map area, there is a large esker complex at the junction of Top Lake and Chedakuz valley. The eskers are perpendicular to, and occur on the western margin of, the Chedakuz valley, indicating that they were formed by water from the Top Lake valley. As the glacier retreated up the Top Lake valley some ice masses remained in the Chedakuz valley and impounded drainage in the Top Lake valley. The glacial lake was able to drain subglacially and formed these large eskers.

GLACIOLACUSTRINE SEDIMENTS

Glaciolacustrine sediments are found in only four places in the study area: on the east side of the Wolf prospect, in two valleys on the south side of the Entiako Spur (Figure 4, Section 93-5), and near Top Lake (Figure 2; Figure 4, Section 93-8). They can be divided into two facies based on grain size and structure: horizontally bedded fine to coarse sand and horizontally laminated fine sands, silts and clays. A shallow-water fan-delta origin is proposed for the sand facies and the finer grained sediments are interpreted to be rhythmically bedded glaciolacustrine deposits.

The coarsest strata in the sand facies are horizontally bedded and trough cross-laminated medium to coarse sand beds up to 25 centimetres thick (Plate 10), commonly with fluid escape, flame and load structures. Parallel-laminated fine to medium sand beds, up to 10 centimetres thick, with dropstones, load structures, faults and deformed beds are common. Climbing ripples occur in well-sorted fine to medium sand beds, usually as a cap to underlying coarser strata. Beds of this facies commonly fine upwards from glaciofluvial gravels below to fine sand, silt and clay facies above.

Fine sands, silts and clays are thinly laminated, horizontally stratified and laterally extensive. Horizontally laminated, normally graded beds of fine sand and silt are the dominant sediments in this facies (Plate 11). Beds of fine sand up to 2 centimetres thick commonly form rhythmic couplets with silt beds, typically less than a centimetre thick. Fine sand and silt may occur in normally graded beds up to 20 centimetres thick. Clay beds are 1 to 5 centimetres thick. High-angle intraformational faulting is locally common, with displacements up to 10 centimetres.

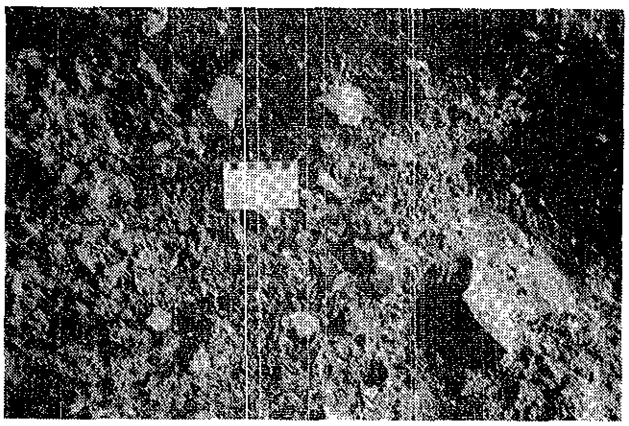

Plate 12: A typical exposure of unsorted, angular colluvial diamicton overlying on bedrock on a steep slope.

Plate 13: Air photograph of the postglacial alluvial fan which has deflected the outlet stream from Top Lake to the south side of the valley. Note the presence of one major channel and at least three abandoned channels. Air photograph BC 7807-311.

POSTGLACIAL FLUVIAL AND ORGANIC SEDIMENTS

Fluvial sediments occur in valley bottoms throughout the area. They include reworked morainal and glaciofluvial deposits as indicated by stream exposures of glaciofluvial delta, terrace, kame and esker deposits, especially in the Fawnie Creek valley. Most streams in the area are meandering streams with gravel channels. Floodplains are dominated by fine sands, silts and organics. In upland areas small gravelly creeks have reworked glacial, glaciofluvial and colluvial sediments and locally are incised into bedrock. The flat, open terrain of Fawnie and Matthews Creek valleys is characterized by marshes and shallow lakes filled with organic sediment. In the southwest part of the map area the Fawnie valley broadens to over 15 kilometres wide. The organic deposits consist of decayed marsh vegetation with minor sand, silt and clay. Organic deposits also occur in the base of some valleys in low areas, as a thin veneer of decaying vegetation over cobble and boulder gravel.

POSTGLACIAL COLLUVIAL AND ALLUVIAL FAN SEDIMENTS

A thin veneer of weathered and broken bedrock clasts in a loose sandy matrix occurs on steep slopes throughout the area (Plate 12; Figure 4, Sections 93-25 and 93-5). These deposits grade downhill into a thicker cover of colluvial diamicton derived from both local bedrock and till. Colluvial veneers are common over tills on steep slopes. Colluvial diamictons are differentiated from till by their loose, unconsolidated character, the presence of coarse, angular clasts of local bedrock, crude stratification and lenses of sorted sand and gravel

Several postglacial alluvial fans occur in the area; the largest and most active is located at the west end of Top Lake (Plate 13). There is a large catchment area upstream from an incised bedrock gully that forms the fan-head channel, and flashy discharge is typical. The alluvial fan has prograded across the western margin of Top Lake and has constrained the outlet stream to the southern side of the valley. Coarse cobble to boulder gravel is actively transported in the main fan channel. Evidence for rapid lateral migration of the modern channel was seen during the course of the field season. Heavy rainfall over a 2-day period resulted in bankfull conditions, channel migration and bank erosion in several areas. Up to several metres of channel aggradation occurred locally. Flooding caused extensive damage, isolating a bridge in mid-stream by eroding the roadbed on either side. The main course of the channel spread across a plain approximately 50 metres wide where previously it had been contained in a channel 5 metres wide. Evidence for many such events on this and other fans in the area is indicated by numerous channel scars on the fan surfaces (Plate 13).

ICE-FLOW HISTORY

Results of ice-flow studies in the area indicate that there was one dominant flow direction towards the east-northeast modified by topographic control during both early and late stages of glaciation. Striation measurements from exposed bedrock across the area typically indicate northeast to east flow, but range from 028° to 103°. Topographic control of ice-flow direction during early glacial phases is indicated by valley-parallel striae on bedrock surfaces that are buried by thick till sequences. At the Late Wisconsinan glacial maximum, ice covered the highest peaks in the region and movement appears to have been unaffected by topography, suggesting an ice thickness in excess of 1000 metres (3000 feet). Crag-and-tail features, drumlins and glacial flutings are present throughout the area and indicate flow towards the east and northeast during full glacial time. Cross-cutting striae in an easterly (075°) trending valley in the northeast part of the area record topographically influenced ice flow during waning stages of glaciation. Early flow is towards 045° and later flow at 075°. Similarly, in the southwest part of the area the full-glacial ice direction was determined to be 070° to 080° with later flow at 089° to 103°.

SUMMARY OF GLACIAL HISTORY

Prior to glaciation, regional drainage was similar to present, westwards from Top Lake and Mount Davidson through the Fawnie valley into the Entiako River system. Advancing ice to the southwest caused flow to reverse and proceed to the east and north through the Top Lake valley. The first lobes of Late Wisconsinan Fraser glaciation ice advancing into the area were probably confined to major valleys. Drumlins, crag and tails, flutings and striations all indicate that when the glaciers were thick enough to be relatively unaffected by topography during full-glacial times, ice flow was east-northeasterly. At the margins of the advancing ice, coarse-grained proglacial outwash was deposited locally in the valley bottoms. Massive, matrix-supported, compact lodgement and melt-out tills were deposited by the advancing ice. During the final stages of deglaciation, loose, sandy gravelly diamictons were deposited on top of the tills by debris flows. Confined subglacial flow created small eskers in the bottom of Van Tine Creek and Fawnie Creek valleys and on the low-lying areas to the southwest of Moose Lake. In the Fawnie Creek valley the glacier downwasted and numerous meltwater channels were cut on the north side of the valley (Plate 8). Gravelly outwash plains formed in the main valley bottoms as large volumes of sediment and water were removed from the ice margin.

This valley was the only outlet through the Fawnie Range for meltwaters from ablating ice south of the Entiako Spur. Stagnant ice masses to the northeast of the map area dammed meltwaters and caused formation of a glacial lake in the Top Lake region. A pitted delta formed where sediment-laden meltwaters entered the western margin of the lake at an elevation of around 1100 metres (3600 feet). Knob-and-kettle topography (Plate 13) indicates the presence of ice blocks within the deltaic sediments. Ten metres of rhythmically bedded sand and silt are exposed along the margin of Fawnie Creek valley suggesting sustained lake activity. A large esker complex is located at the eastern end of the Top Lake valley where meltwaters flowed under the stagnant ice masses in the Chedakuz valley.

Other smaller lakes also formed locally along the margins of the retreating ice. For example, in the Wolf area, glaciolacustrine sediments occur 75 metres above the base of a north-trending valley indicating local ice damming. In addition, meltwaters, flowing off the Entiako Spur on the north side of the Fawnie valley, were dammed by stagnant ice creating short-lived glacial lakes in the side valleys. A sequence of cobble-boulder gravel, fining upward to stratified fine sand, silt and clay, exposed in one of the valleys, records the change from a glaciofluvial to a glaciolacustrine environment. In another valley, a thick section of well-sorted, well-bedded, rippled fine to coarse sand is exposed in a coarsening upward sequence which suggests delta progradation into a lake.

EXPLORATION IMPLICATIONS

Exploration programs in drift covered regions must rely on an understanding of glacial processes and the glacial history of the area (Coker and DiLabio, 1989). Glaciers moving across mineralized bedrock erode and incorporate mineralized debris into the ice mass. Dilution of the mineralization occurs down-ice and forms a dispersal train within the till. The dispersal train may be strongly anomalous but very small at the head (source) and becomes less anomalous but much larger towards the tail. Dispersal train anomalies may be hundreds to thousands of times larger than the original bedrock source and form large targets for geochemical exploration (DiLabio, 1990). Dispersal trains are commonly very thin in comparison with their length and have clear lateral and vertical contacts with the surrounding till. In the simplest case of unidirectional ice-flow, mineralized material at a point source will be eroded, transported and redeposited to produce a ribbon-shaped dispersal train parallel to ice flow (Fox *et al.*, 1987; Gravel *et al.*, 1991). Variations in the ice-flow direction, caused by topographic irregularities or changing dynamics at the base of the ice may cause the anomaly to curve or to form a fan-shaped dispersal train. In more complex areas, where there have been numerous flow directions during glaciation or multiple glaciations, the anomaly may be widespread and difficult to trace to the source.

Sampling of basal tills rather than other types of surficial materials is recommended in this region for several reasons:

- Basal tills are deposited in areas directly down-ice from their source and therefore mineralized materials dispersed within the tills can be more readily traced to their origin than can anomalies in other sediment types. Processes of dispersion in ablation tills, glaciofluvial sands and gravels, and glaciolacustrine sediments are more complex and they are typically more distally derived than basal tills.

- The dominance of one main regional ice-flow direction throughout much of the last glacial period has resulted in a simple linear, down-ice transport of material. This makes tracing of basal till anomalies to source relatively easy compared to regions with a more complex ice-flow history.

- Due to the potential for the development of large dispersal trains, mineral anomalies in basal tills may be readily detected in regional surveys.

To reflect mechanical dispersion processes, samples should be collected from the C mineral soil horizon. This horizon remains comparatively unaffected by pedogenic processes which occur in the A and B horizons. Poor results of some traditional geochemical soil sampling programs may be due to indiscriminate sampling of B and even Ae horizons. Sedimentologic data should be collected at all sample sites in order to distinguish till from glacigenic debris-flow, colluvium, glaciofluvial or glaciolacustrine sediments. These sediments have different processes of transportation and deposition which must be recognized in order to understand associated mineral anomaly patterns. For example, local variations will be reflected in some sediments while regional trends may be evident in others. Analysis of these sediments will be useful only if their origin is understood.

A basic understanding of ice-flow direction, glacial dispersal patterns, and transportation distances is required for successful drift exploration programs. Interpretation of data with respect to glaciation may provide the explorationist with new avenues to explore for bedrock sources of mineralized float or geochemically anomalous soil samples.

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