QUATERNARY GEOLOGY AND ICE FLOW HISTORY OF THE BABINE COPPER PORPHYRY BELT, BRITISH COLUMBIA (NTS 93 L/NE, M/SE)

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INTRODUCTION

This paper provides an overview of surficial geology, Quaternary stratigraphy and ice flow history studies conducted in the Babine porphyry belt and surrounding regions by the British Columbia Geological Survey. The studies were conducted in conjunction with regional till geochemistry (Levson *et al.*, 1997), lake sediment geochemistry (Cook *et al.*, 1997) and bedrock geology mapping (MacIntyre *et al.*, 1997) components. These studies are part of the Nechako National Mapping (NATMAP) Project, coordinated by the Geological Survey of Canada and the British Columbia Geological Survey. The components of the NATMAP project discussed in this paper were also performed in collaboration with researchers from the Ministry of Forests.

Time-stratigraphic, 1:50 000, surficial geology mapping, incorporating local and regional ice flow history data, was completed on the Nakinilerak Lake map sheet (NTS 93 M/8) in 1996 (Figure 1). This work extends 1995 mapping on the Fulton Lake - Old Fort Mountain map sheets (93L/16 and M/1, respectively Huntley *et al.*, 1996) and will provide a complete overview of the surficial geology of the Babine copper porphyry belt. The main objectives of the surficial geology mapping are to understand and map the distribution of Quaternary deposits, decipher the glacial history and ice-flow patterns and locate areas most suitable for conducting drift exploration programs. Stratigraphic and sedimentologic studies of Quaternary deposits were conducted in order to define the glacial history and aid in interpreting till geochemical data.

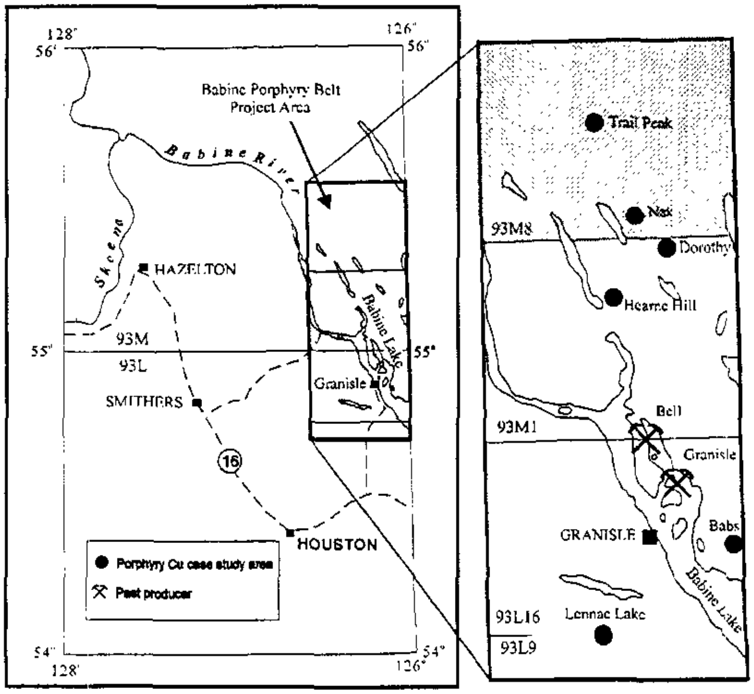


Figure 1. Location map of the study region showing major copper porphyry prospects investigated in this study.

PREVIOUS QUATERNARY STUDIES

Reconnaissance (1:250 000-scale) mapping of Quaternary deposits in the Nechako Plateau was conducted by Tipper (1971). Wittneben (1981) completed 1:50 000 scale terrain mapping in parts of the Nechako map sheet (NTS 93 M/NW, NE, SW). Most recently, Plouffe (1994a, b) completed 1:100 000-scale surficial geology mapping in the central part of the Nechako Plateau, east and southeast of the Babine porphyry belt. Levson and Giles (in press) discussed the Quaternary geology of the Nechako Plateau and the surficial geology of the southern part of the Babine region was described by Huntley *et al.* (1996).

PHYSIOGRAPHY AND LANDFORMS

The Babine porphyry belt occurs in the northernmost part of the Nechako Plateau physiographic region (Holland, 1976). The Nechako Plateau is an area of low relief compared to the Hazelton Mountains to the west and the Skeena Mountains to the north. The Bait Range, at the southern end of the Skeena Mountains, occurs in the north central part of the 1996 map area (Figure 2). Surface elevations range from about 700 to 1000 metres in the plateau and the highest mountain in the map area is Frypan Peak at 1932 metres (6337 ft). The Bait Range and the topographically high area to the southeast, create a major drainage divide. Beaverdale, Dust and Sinta creeks flow southeasterly from this area towards the Northwest Arm of Takla Lake and Tahlo Creek flows into Morison Lake in the southwest corner of the map area (Figure 2). Low lying areas in the southwest and northeast parts of the map sheet are poorly drained and occupied by numerous lakes and marshes.

During Late Wisconsinan glaciation, ice moved into the Nechako Plateau from the Coast Mountains to the west and southwest and from the Skeena Mountains to the northwest, before flowing easterly and northeasterly towards the Rocky Mountains (Tipper, 1971). Well developed flutings and drumlinoid ridges, oriented parallel to the regional ice-flow direction, are dominant features on the plateaus. During deglaciation, stagnant ice topography, large esker complexes, glaciofluvial deposits and meltwater channels, developed in many areas. Much of the variation in topography and surficial geology in the plateau areas is due to these features. In low-lying regions, such as the valleys now occupied by Babine and Takla lakes, large glacial lakes formed and deposited extensive belts of glaciolacustrine sediments, generally below 950 metres elevation. Topography in these areas is subdued and older glacial landforms are often difficult to recognize.

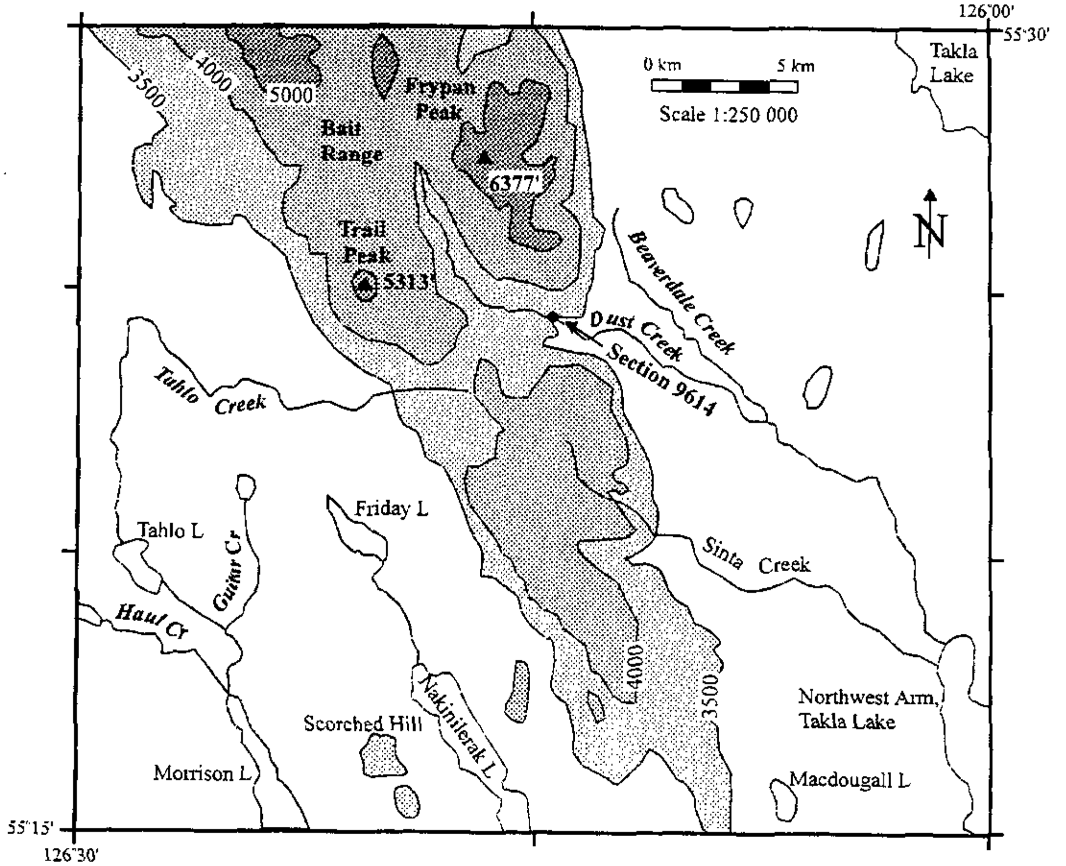


Figure 2. Generalized topography and place names in the 1996 map area (NTS 93 M/8).

FIELD PROCEDURES

Surficial geology mapping was completed by compilation of existing terrain-mapping data, interpretation of air photographs, field checking and stratigraphic and sedimentologic investigations of Quaternary exposures in the study areas. Ice-flow history was largely deciphered from the measurement of the orientation of crag-and-tail features, flutings, drumlins and striae (Photo 1).

Logging road access to the 1996 map area was limited to the westernmost and easternmost sides of the map sheet. Other parts of the map area were accessed by all-terrain vehicle, motor boat, canoe and helicopter.

Sedimentologic data were collected at all sample sites in order to distinguish till from glacigenic debris flow, colluvium, glaciofluvial or glaciolacustrine sediments. Sedimentologic data collected at each sample site 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, presence of striated clasts, pebble lithologies, and sediment genesis and thickness. Further information was noted on soil horizons, local slope, bedrock striae, bedrock lithology, clast provenance and abundance and type of mineralized clasts. Field sites include natural river cuts, wave-cut benches on lake shorelines and anthropogenetic exposures (roadcuts, borrow pits, soil pits and trenches).

QUATERNARY STRATIGRAPHY AND SURFICIAL GEOLOGY

LATE WISCONSINAN GLACIAL DEPOSITS AND OLDER SEDIMENTS

Morainal sediments in the Nechako Plateau region were assigned by Tipper (1971) to the Fraser glaciation which is dated in several parts of British Columbia as Late Wisconsinan (Ryder and Clague, 1989). A Late Wisconsinan age for the last glaciation in the region is also indicated by radiocarbon dates on wood and mammoth bones recovered from lacustrine deposits under till at the Bell Copper mine (NTS 93 L/16) on Babine Lake. Single fragments of spruce (*Picea* sp.) and fir (*Abies* sp.), yielding dates of 42 900±1860 years B.P. (GSC-1657) and 43 800±1830 years B.P. (GSC-1687), and a date of 34 000±690 years B.P. (GSC-1754) on mammoth bone collagen from the interglacial sediments (Harington *et al.*, 1974), indicate that the overlying till was deposited during the Late Wisconsinan glaciation. Palynological data from interglacial lake sediments are indicative of a shrub tundra vegetation.

The Quaternary stratigraphy of the northern Nechako Plateau has been reconstructed from a number of exposures in the region. Quaternary sediments underlying till are rarely exposed in the survey areas. The most complete stratigraphic sections encountered in the region mainly occur in the vicinity of the Nechako Reservoir (Levson and Giles, in press). The stratigraphic record of pre-Late Wisconsinan events elsewhere in the area was largely removed during the last glaciation.

A representative stratigraphic section from the Babine porphyry belt is provided in Figure 3. Exposures at this site, located on Dust Creek reveal a thick sequence of advance-phase glaciolacustrine and glaciofluvial deposits (Photo 2) overlain by till deposited during the last glaciation and finally by post-glacial gravels and sands. The lowest exposed unit (Figure 3) overlies bedrock and consists of well stratified, very dense sands, silts and clays. These sediments are interpreted as proximal glaciolacustrine deposits. Their stratigraphic position indicates that they probably were deposited during the advance phase of the last glaciation in the region. Their presence in the Dust Creek valley indicates that glaciers in the Late Wisconsinan occupied the Takla Lake valley before the southern Bait Ranges were completely ice covered. The resulting ice-damming of the Dust Creek drainage resulted in the development of a glacial lake in that valley.

A thick sequence of gravels and sands (Figure 3; Photo 2) that overlie the glaciolacustrine deposits are interpreted as a prograding deltaic sequence that was deposited by water flowing out from the Bait Range. Large-scale, steeply dipping, planar cross-beds in this unit are interpreted to be forset beds deposited in this prograding delta. Paleoflow directions are highly variable but generally southerly. The forset gravels are erosionally overlain by a trough and planar cross-bedded unit of coarse gravels interpreted as channelized topset beds. A locally present, overlying unit of bedded fine sands also may be delta top sediments that were deposited when the main gravelly feeder channels shifted to another part of the delta. The entire sand and gravel sequence is sharply overlain by a massive, matrix supported, dense, silty diamicton, interpreted as a till. The upper part of the diamicton is less dense, has a gravelly-sand matrix and locally is crudely bedded. This unit probably was deposited as a series of debris flows during deglaciation. The capping gravels and sands at the site are interpreted to be glaciofluvial sediments deposited prior to incision of the modern Dust Creek valley, probably beginning in the early Holocene.

Glacial deposits form a cover of variable thickness across much of the Nechako Plateau and occur mainly as fluted, drumlinized or relatively flat topography. Hummocky or kettled topography also occurs in some areas but is relatively uncommon in the Babine region. Morainal sediments include dense, matrix-supported, silty diamictons interpreted as lodgement and melt-out tills. Compressive deformation structures, such as shear planes, occur near the base of the till, and overturned folds and thrust faults, interpreted as glaciotectonic structures, are locally present in the upper part of the underlying glaciofluvial sediments. Loose, massive to stratified, sandy diamictons of inferred debris-flow origin often commonly occur at the surface. These diamictons are

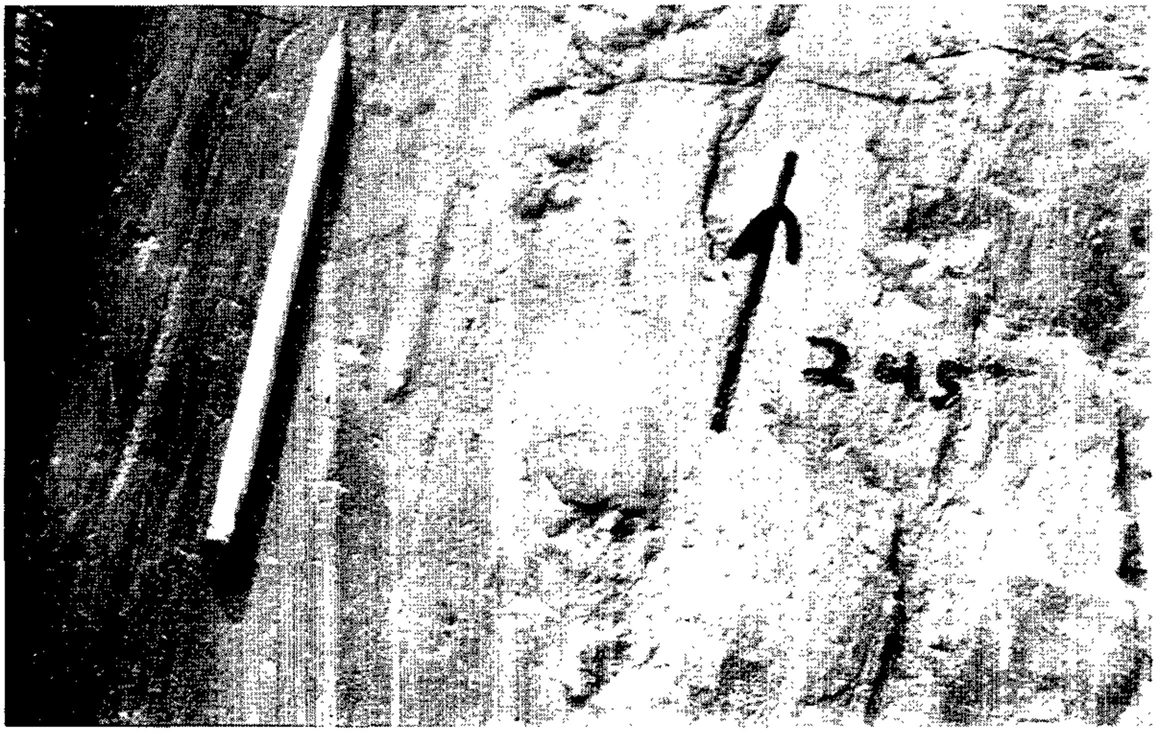


Photo 1. Striae with directional indicators on bedrock in the southern Babine Mountains.

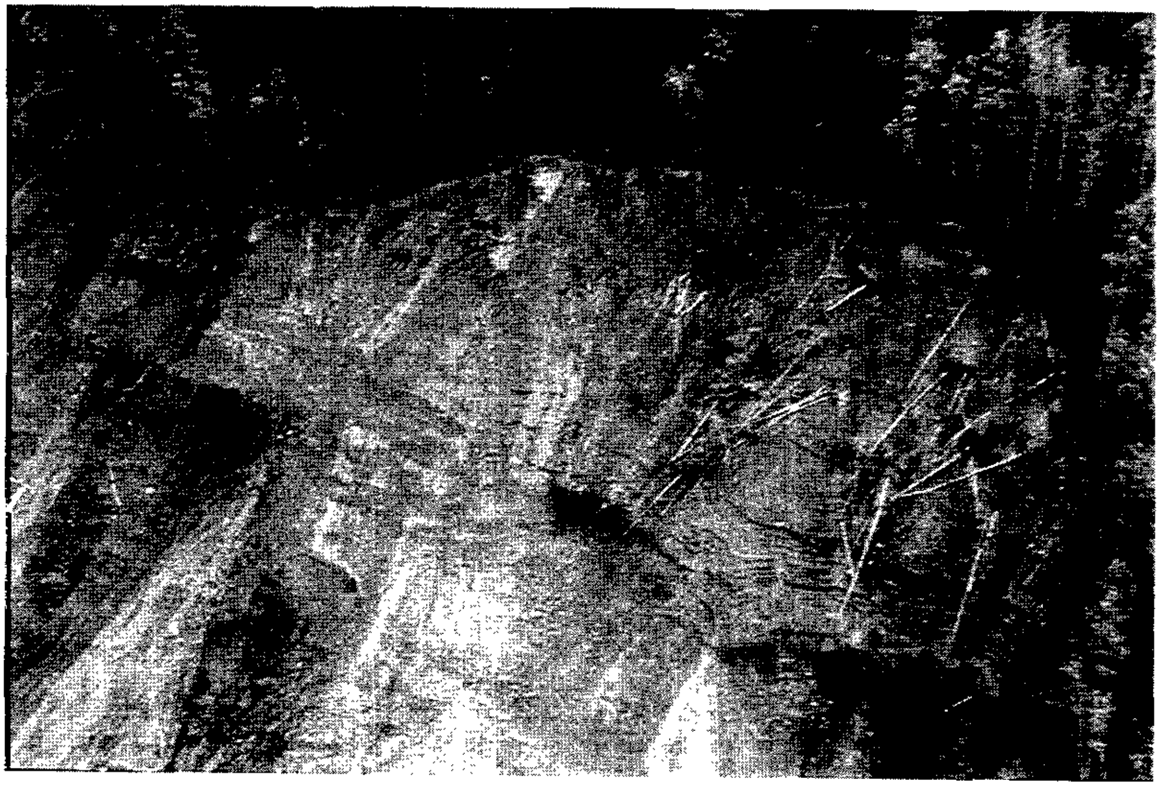
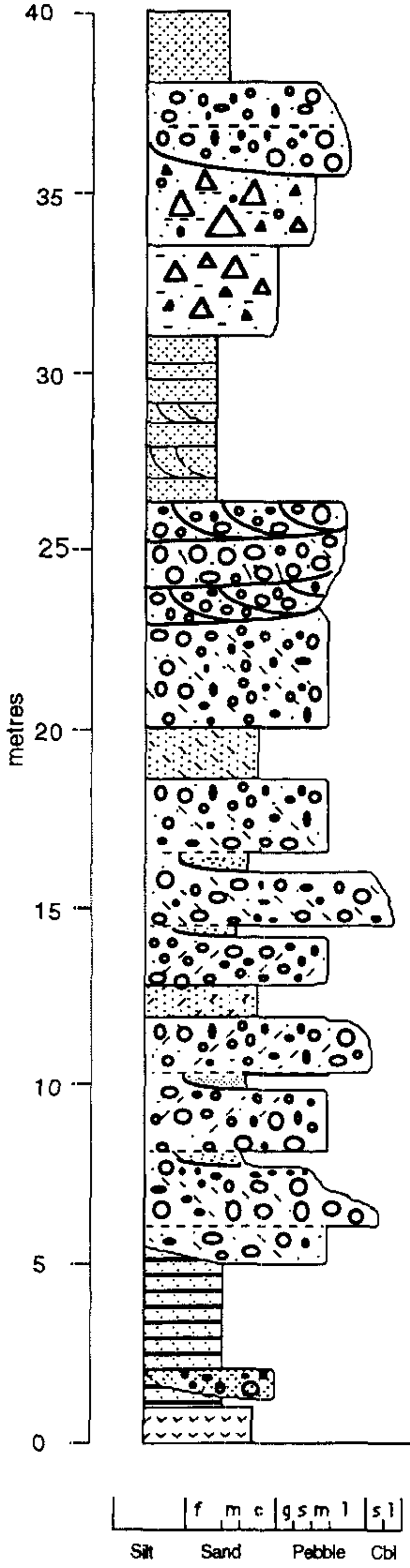


Photo 2. Upper part of glaciofluvial deltaic complex exposed along Dust Creek in the southeastern part of the Bait Range.



Description	Interpretation
Fine to medium sand: horizontally bedded; well sorted; locally occurs as a large channel-form unit; lower contact sharp and horizontal	Retreat-phase *glaciofluvial* gravels and channel-fill sands
Large pebble gravel: crude horizontal bedding; poorly sorted; lower contact sharp and trough-shaped.	
Gravelly diamicton: massive to crudely bedded; matrix *supported; gravelly sand matrix; loose; clasts* subangular to subrounded; striae rare; lower contact sharp and subhorizontal.	*Late-glacial* debris flow sequence
Silty diamicton: massive; matrix supported; 20% clasts; moderate to high density; moderate fissility; well jointed; clasts subangular to subrounded; striae common; lower contact sharp and subhorizontal.	Late-Wisconsinan basal meltout and lodgement till
Fine sand: mainly horizontal bedding, some trough cross-bedding; well sorted; poorly exposed.	Advance-phase glaciofluvial delta topset sequence
Medium to large pebble gravel: large-scale trough and planar cross-bedding; lower contact sharp and trough-shaped.	
Interbedded pebble gravel and fine to coarse sand: some cobble beds; large-scale planar cross-bedding; gravel beds 1 to 3 m thick; sand beds 0.2 to 2 m thick; gravels clast-supported, matrix-filled, some openwork; beds dip steeply (18° to 25°); dip directions variable (040° to 320°), often *southerly; lower contact sharp and planar, dipping* steeply to the south.	Advance-phase glaciofluvial delta foreset sequence
Fine to medium sands and some silts and clays: parallel bedding; some climbing ripples; parallel *laminated clays in lower 3 m;* very dense; *lowest m* at one site is a small pebble gravel with sand interbeds; lower contact covered but bedrock is exposed within a few metres downslope.	Advance-phase glaciolacustrine deposits
Andesite: bedded tuff?; very fine grained; green oxidized; dips 42° towards 305°	Bedrock

Figure 3. Stratigraphy of Quaternary sediments exposed at the Dust Creek section (Section VLE-9614; see Figure 2 for location).

often interbedded with gravels and sands or fine sediments.

Basal tills usually unconformably overlie bedrock or, more rarely, older deposits. They often are overlain by glacigenic debris-flow deposits, glaciofluvial deposits or, on slopes, by diamicton of colluvial origin. Till thickness varies from less than a metre along bedrock ridges and steep slopes to several tens of metres in main valleys and in the lee (down-ice) of bedrock highs. Thick exposures of till (>10 m) also occur locally in narrow valleys oriented at high angles to the regional ice-flow direction. In many areas within valley bottoms, morainal sediments are largely buried by glaciofluvial, fluvial and organic sediments.

LATE WISCONSINAN DEGLACIAL DEPOSITS

Deposits formed during deglaciation include both glaciofluvial and glaciolacustrine sediments. Glaciofluvial deposits in the 1996 map area occur as outwash plains, eskers, kames, terraces and fans in valley bottoms and along valley flanks. They consist mainly of poorly to well sorted, stratified, pebble and cobble gravels and sands of variable thickness. Eskers and esker complexes are locally present. They are characterized by sinuous, gravel ridges (Photo 3) that formed in subglacial tunnels. A well developed esker complex (Photo 3) is present in the region northwest Tahlo Lake. The eskers trend southeasterly and straddle the boundary between the Nakinilerak (NTS 93 M/8) and Netalzul Mountain (93 M/7) map sheets. They are composed mainly of stratified gravels and sands and some diamicton.

Hummocky topography, consisting of ridges and knobs of sand and gravel with large kettles, locally indicates the presence of ice blocks within gravelly sediments during deposition of glaciofluvial outwash. Hummocky topography is present mainly in the Macdougall Lake area and in the region a few to several kilometres north of Tahlo Lake. Large kame deposits are uncommon but locally developed along the margins of the stagnating ice and in association with eskers.

Glaciofluvial gravels and sands deposited in front and along the margins of retreating glaciers are widespread in the region. They are especially common within the Dust Creek and Sinta Creek valleys (Figure 2). Deposition of these sediments likely occurred as ice retreated into the Bait Range and glaciofluvial drainage extended down the Dust and Sinta creek valleys into the Northwest Arm of Takla Lake. A large glaciofluvial system extending north of lower Dust Creek towards Takla Lake in the northeast corner of the map area (Figure 2) may have developed either in front of ice retreating up the Takla Lake valley or along the west margin of the Takla Lake glacier.

Exposures of glaciolacustrine sediments occur mainly in low-lying areas, often near modern lakes. Lake levels were at least locally controlled by ice dams. Maximum lake levels in large valleys in the region such as the Babine and Takla Lake valleys are recorded by the upper elevation of deltaic deposits at about 760 metres above sea level. Exposures in these raised deltas reveal well stratified, sands and gravels, commonly with normal faults that formed when the deltas partially collapsed as lake levels dropped (Photo 4). Isolated glaciolacustrine and glaciofluvial deltaic deposits occurring at higher elevations reflect more localized ice damming in smaller tributary valleys (Photo 2).

HOLOCENE FLUVIAL, COLLUVIAL AND ORGANIC DEPOSITS

The most dominant Holocene deposits in the region are extensive areas of organic deposits (Photo 5). Low lying areas in the relatively low relief regions west and east of the Bait Range are characterized by numerous marshes and shallow lakes filled with organic sediment consisting of decayed marsh vegetation with minor sand, silt and clay. Holocene fluvial sediments in the region are dominated by floodplain silts, fine sands and organics and channel gravels.

Colluvial deposits are most common in the Bait Range and in the high relief areas west and east of Nakinilerak Lake and west of the Northwest Arm of Takla Lake. Steep slopes commonly have a thin veneer of weathered and broken bedrock clasts in a loose sandy matrix. These deposits grade downhill into a thicker cover of colluvial diamicton derived from both local bedrock and till remobilized by gravity after deposition. Colluvial veneers commonly overlie thin tills on steep slopes. Thick accumulations of talus are relatively uncommon due to the overall subdued topography, but they do occur below steep rocky cliffs that are locally present in the more mountainous parts of the Bait Range (Photo 6).

A number of large postglacial alluvial fans and fan deltas occur in the map area, especially along the margins of large lakes such as Morison and Nakinilerak lakes and the Northwest Arm of Takla Lake. Extensive areas of fluvial silts and sands also occur along the southeast-trending valleys that lie northwest of each of these lakes. These fluvial sediments are locally underlain by glaciofluvial gravels and in flat-lying areas they are commonly overlain by organic deposits.

ICE-FLOW HISTORY

Study of ice-flow history, glacial dispersal patterns and transportation distances are required to locate the bedrock sources of mineralized float or geochemically anomalous soil samples. Results of ice-flow studies in the Babine porphyry belt indicate that the dominant flow direction during the last part of the Late Wisconsinan glaciation was southeasterly (about 145°). Crag-and-tail features, drumlins and glacial flutings are present throughout the region and reflect this regional trends (Photo 7). Many of these features have formed by subglacial water as well as ice erosion but they generally parallel regional dispersal patterns (Levson and Giles, in press). This is because subglacial meltwater flows under active ice respond to the driving potential created by the surface slope of the glacier and therefore are generally parallel to ice-flow direction (Kor *et al.*, 1991).

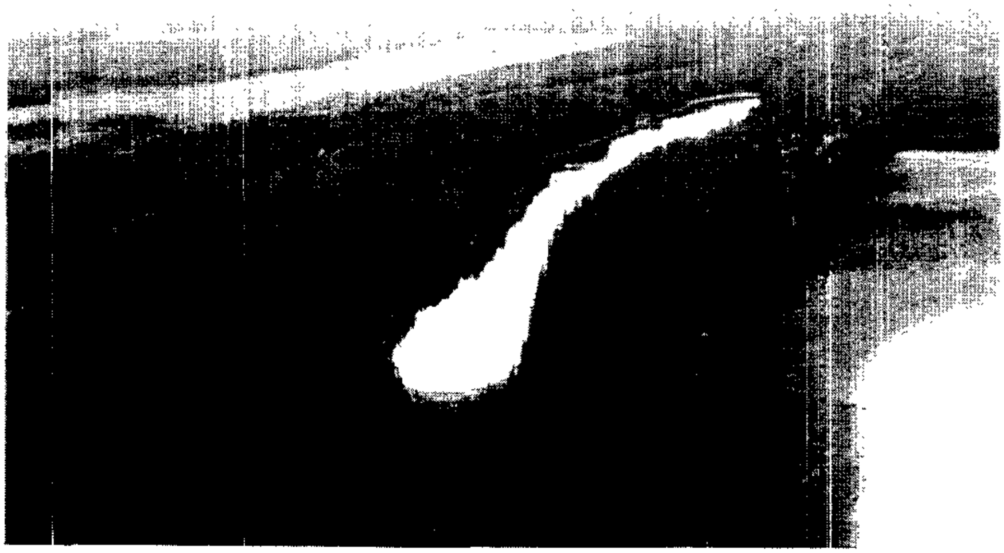


Photo 3. Esker ridges north of Tahlo Lake on the boundary of NTS map sheets 93M/7 and M/8 (Figure 1).

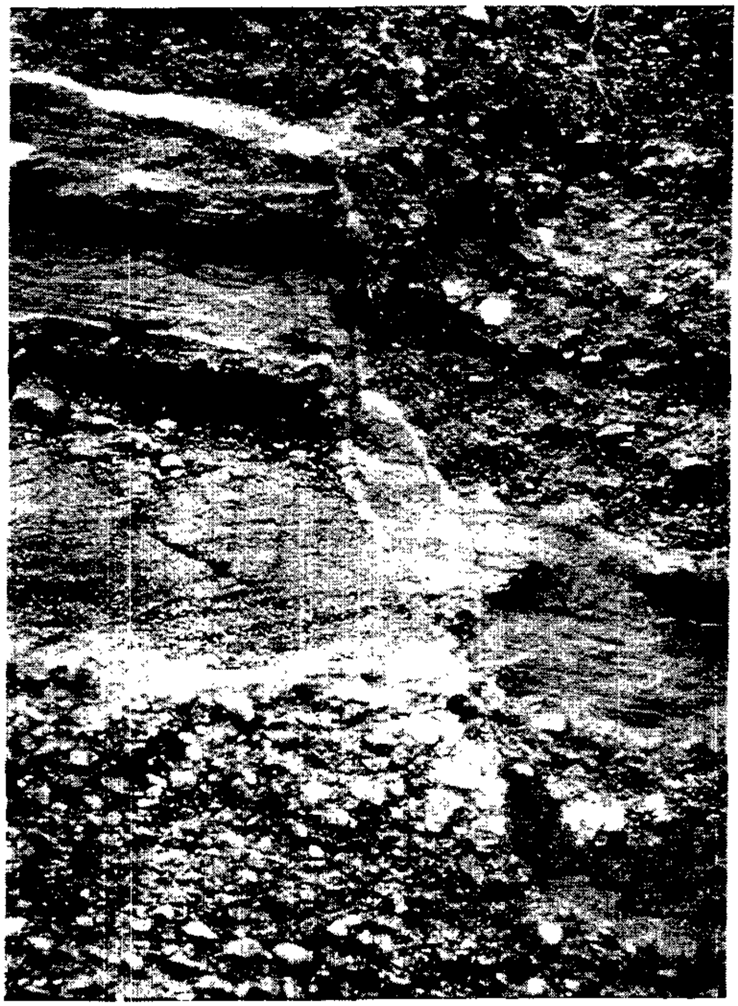


Photo 4. Small-scale normal faulting in sands and gravels in a raised glaciofluvial delta deposit near Babine Lake. Normal faults of varying size are abundant in the deposit and indicate collapse toward the valley centre, probably as a result of lowering of Glacial Lake Babine in the late Pleistocene.

Photo 5. Organic soil and peat, more than 1 metre thick, exposed along a creek channel cutting through a small bog near Trail Peak

Photo 6. Talus slopes on the south side of a cirque at the headwaters of Frypan Creek in the Bait Range.

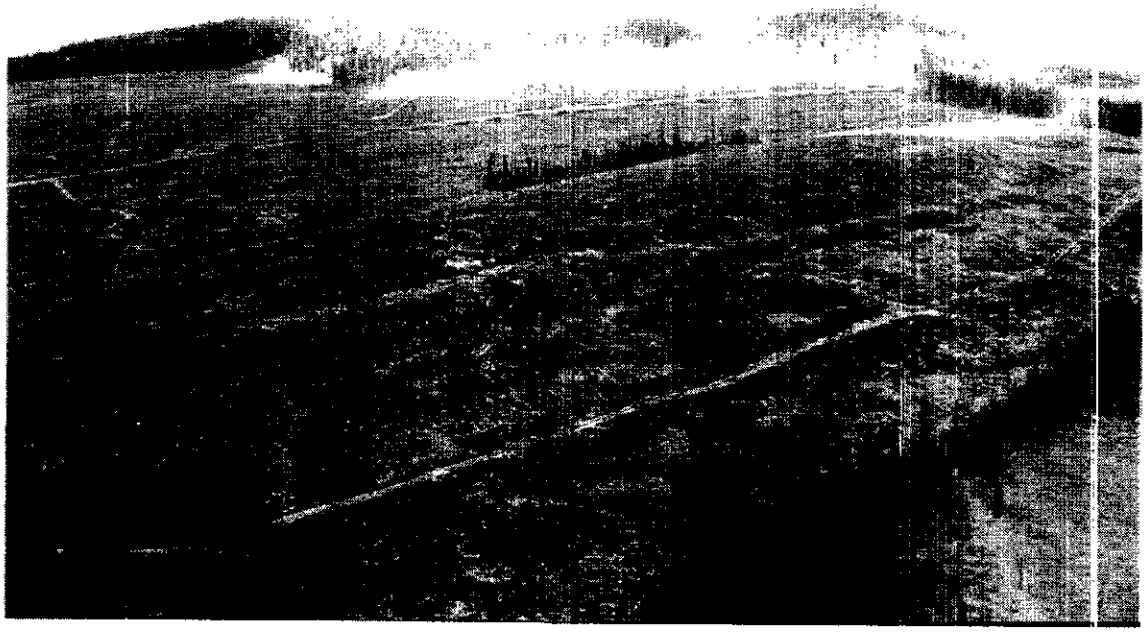


Photo 7. Well developed fluted and drumlinized topography exposed in a clear-cut north of Babine Lake. Ice-flow direction is from the right to the left (southeasterly).

At the Late Wisconsinan glacial maximum, ice covered all but the highest peaks in the region and movement appears to have been relatively unaffected by topography. In the Bait Range, the ice surface was in excess of 1950 metres as indicated by glacial erratics and regionally trending striae and flutings on top of Frypan Peak (elevation 1931 m). A lateral moraine on the south flank of a high mountain in the northern part of the 1996 map area (Photo 8), indicates that an active ice margin stabilized in this region at an elevation of approximately 1600 metres. Topographic control of ice flow during the latter phases is most apparent in the Bait Range where relief is high. Topographically influenced ice flow in this area is also clearly indicated by the presence of well developed cirque basins on the north and east facing sides of large mountains (Photo 6). During deglaciation, ice flow was increasingly controlled by topography as the glaciers thinned. Cirque glacier activity dominated during the later phases of the last glaciation and may have extended into the Holocene.

In the southern Babine Mountains, anomalous westerly ice-flow indicators are present. These include well developed roche-moutonnée (Photo 9) that locally indicate upslope ice-flow toward the west over the southern end of the Babine Range. Similar westerly ice-flow indicators have also been discovered to the southeast as far as the Maxan and Goosly lakes area. Westerly ice-flow patterns in the northern Nechako Plateau were previously reported by Tipper (1995). However, this study has extended their distribution further to the south and east and new evidence on the timing of this event has important implications for the Quaternary history of the region.

Westerly ice flow in this region appears to have occurred at a late stage in the last glaciation as indicated by stratigraphic, lithologic and geomorphic criteria. This includes the presence of westerly ice-flow indicators at the surface in areas where preservation from later ice erosion would not likely occur (*e.g.* in stoss-side positions). For example, westerly ice-flow indicators in the Dome Mountain area are preserved on the top of the mountain as well as on the east side at relatively low elevations. During the last glaciation, ice flowed along the east side of the mountain from the Babine Lake area and clearly would have eroded or at least partially obscured the exposed features on the east side of the mountain. In addition, investigations of glacial dispersal in surface tills in these areas indicate westerly dispersal. Tracing of erratics with distinctive lithologies and known source areas in the Dome Mountain region, for example, has

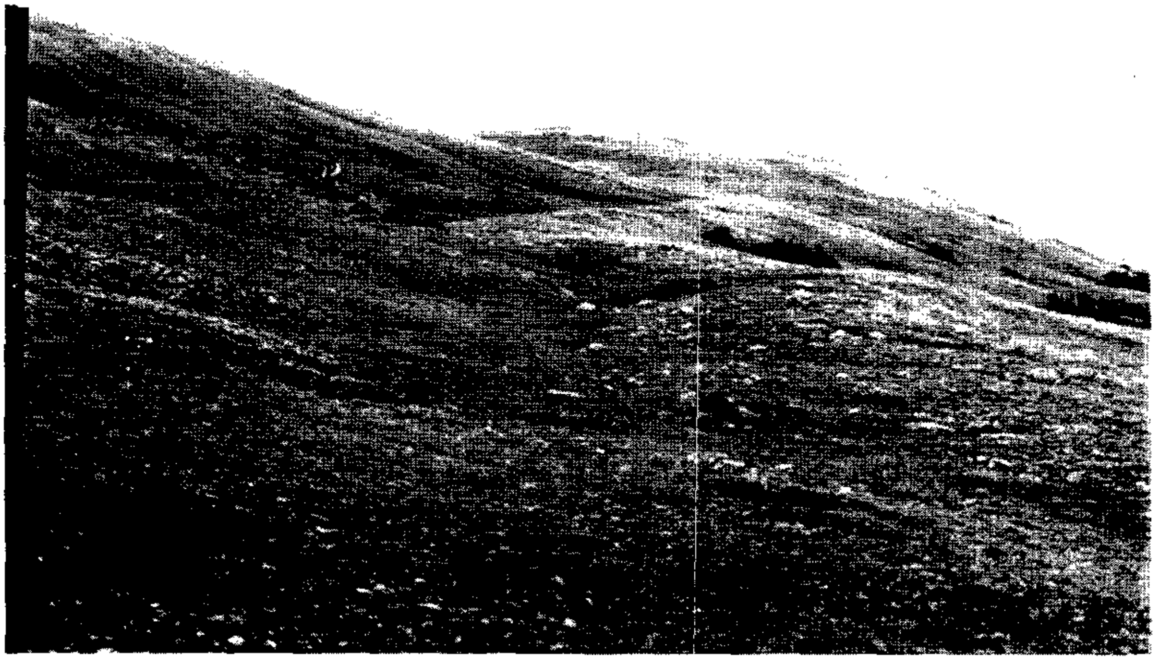


Photo 8. Lateral moraine on the south flank of an unnamed mountain northwest of Frypan Peak. The moraine is unusally well preserved and extends for a few kilometres along the side of the mountain. It marks the location of a significant late-glacial ice margin in the region at an elevation of about 1600 metres. Note the large number of erratics in places on the moraine surface. The person (at left) is standing on bedrock outcropping above the moraine.

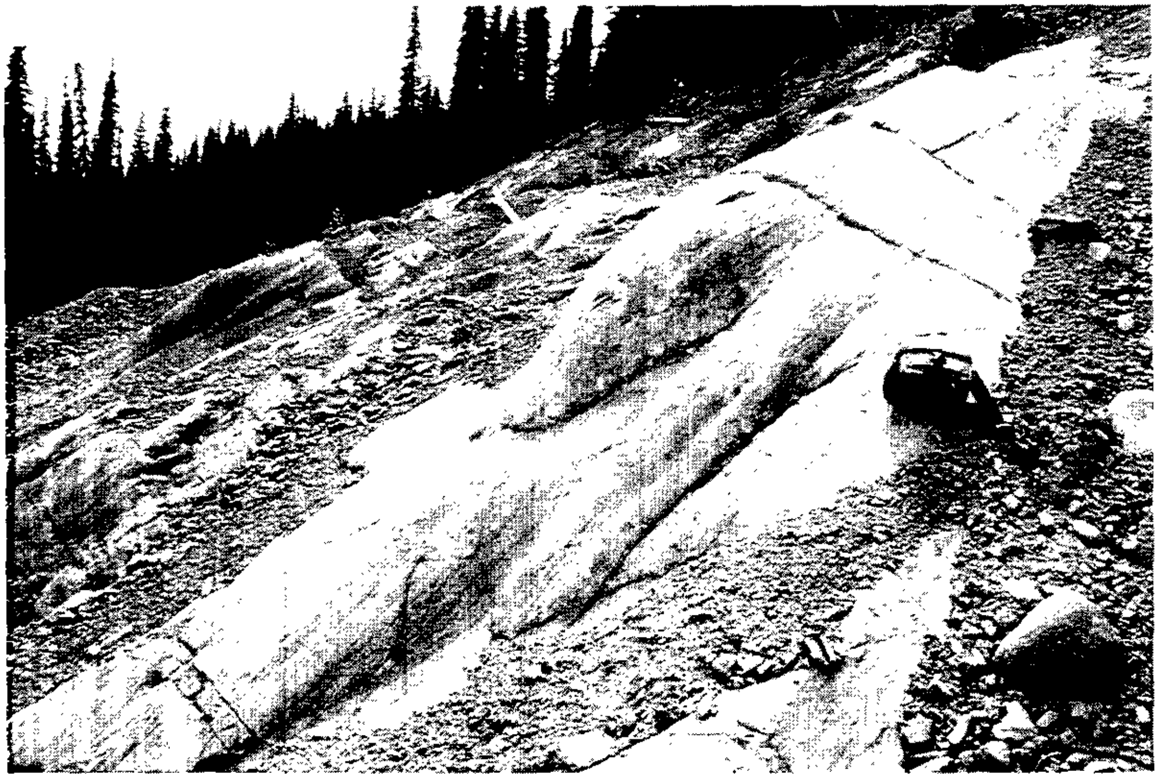


Photo 9. Roche moutonée on the east side of Dome Mountain in the southern Babine Mountains. Paleoflow indicators are westerly at the site (see text for discussion).

shown substantial westerly and upslope transport of the erratics from their source areas.

Derivation of westerly ice-flow features during the later part of the Late Wisconsinan glaciation differs with the previous interpretation of Tipper (1994) who postulated that the westerly ice flow patterns represented a relict flow pattern from an earlier glaciation or possibly from the maximum phase of the last glaciation when movement of ice towards the Coast Mountains occurred as the result of the development of ice dome in the central part of the Interior Plateau. We suggest, however, that since westerly ice-flow indicators occur only locally and developed late in the last glaciation, they probably reflect a more local phenomena. We suggest that rapid calving of tidewater glaciers in large valleys on the west side of the Coast Mountains, such as the Skeena River valley, may have resulted in a draw-down of ice in that area. Rapid calving and significant lowering of the ice surface in these valleys, may have resulted in the eastern migration of local ice divides, the 'capture' of glacial ice from east of the Coast Mountains and the local reversal of ice flow into valleys such the Skeena and some of its tributary valleys. This hypothesis is consistent with the development of westerly ice flow indicators late in the last glaciation and with their relatively limited extent. The full extent, timing and duration of this westerly ice flow event and its influence on glacial dispersal has not yet been determined but is the subject of ongoing research.

SUMMARY

Late Wisconsinan glaciers first advanced into the Babine region along major valleys such as the Babine and Takla valleys. Damming of tributary drainage and the development of proglacial lakes occurred in some valleys such as the Dust Creek valley in the Bait Range. Meltwater streams flowing from the advancing ice, deposited coarse-grained proglacial outwash plains in the valley bottoms and glaciofluvial deltas developed where the streams entered the proglacial lakes. Debris-flow sediments were deposited with the outwash and proglacial lake sediments. Lodgement and meltout tills were eventually deposited by the glaciers as they advanced southeasterly over the entire region. Drumlins, crag-and-tails, flutings and striae in many areas crosscut major topographic highs, and indicate that the ice was thick enough to be relatively unaffected by topography during full-glacial times.

Results of ice-flow studies indicate that in most areas in the Babine porphyry belt, the dominant flow-direction was southeasterly. Glacial dispersal patterns appear to be dominated by this regional ice-flow direction. In many areas, the regional ice-flow was modified by topographic control during both early and late stages of glaciation but effects of these modifications on glacial dispersal patterns are restricted mainly to areas of relatively high relief. For example, glaciers in the Bait Range resulted in well developed cirque basins on the north and east facing sides of large mountains there.

In the southern Babine Mountains and further to the south and east, a late glacial, westerly ice-flow event occurred, the full extent of which is currently being investigated. This event apparently did not influence glacial dispersal in the Babine porphyry belt but it probably did have an effect further south. Westerly ice flow in this part of the Nechako Plateau is regionally anomalous and may have occurred when a late-glacial ice divide in the Coast Mountains locally migrated into the interior. A postulated driving mechanism is the rapid calving of tide-water glaciers, such as the Skeena River valley glacier, which may have allowed for significant lowering of glaciers in those valleys relative to ice in the interior and the subsequent capture of glacial ice from drainage areas to the east.

Morainal sediments deposited during the last glaciation are widespread in the Interior Plateau and form a cover, varying in average thickness from a few to several metres in low-lying areas, to less than a metre in upland regions. During deglaciation, loose, sandy gravelly diamictons were deposited on top of the tills by debris flows. Stagnant ice masses locally resulted in the development of large esker complexes and dammed meltwater to create glacial lakes and associated glaciofluvial deltas. Gravelly outwash plains covered the main valley bottoms as large volumes of sediment and water were removed from the ice margin. Glaciofluvial sediments consist mainly of poorly to well sorted, stratified, pebble and cobble gravels and sands. Glaciolacustrine sediments are common in large valleys, generally at elevations below 950 metres, often near modern lakes.

During postglacial times, the surficial geology of the area was modified mainly by fluvial activity and the local development of alluvial fans in the valley bottoms, as well as by colluvial reworking of glacial deposits along the valley sides.

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REFERENCES

Cook, S.J., Jackaman, W., Lett, R. and Sibbick, S. (1997): Regional Geochemical Survey Program: Review of 1996 Activities; *in* Geological Fieldwork 1996, Lefebure, D.V., McMillan, W.J. and McArthur, J.G, Editors, *B.C. Ministry of Employment and Investment,* Paper 1997-1, this volume.

Harington, C.R., Tipper, H.W. and Mott, R.J. (1974): Mammoth from Babine Lake, British Columbia; *Canadian Journal of Earth Sciences,* Volume 11, pages 285 - 303.

Holland, S.S. (1976): Landforms of British Columbia, A Physiographic Outline; *B. C. Ministry of Energy, Mines and Petroleum Resources,* Bulletin 48, 138 pages.

Huntley, D.H., Stumpf, A., Levson, V.M. and Broster, B.E. (1996): Babine Porphyry Belt Project: Quaternary Geology and Regional Till Geochemistry Sampling in the Old Fort Mountain (93M/01) and Fulton Lake (93L/16) Map Areas, British Columbia; *in* Geological Fieldwork 1995, Grant, B. and Newell, J.M., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1996-1, pages 45-53.

Kor, P.S.G., Shaw, J. and Sharpe D.R. (1991): Erosion of Bedrock by Subglacial Meltwater, Georgian Bay, Ontario: A Regional View; *Canadian Journal of Earth Sciences,* Volume 28, pages 623-642.

Levson, V.M. and Giles, T.R. (in press): Quaternary Geology and Till Geochemistry Studies in the Nechako and Fraser Plateaus, Central British Columbia. in Interior Plateau Geoscience Project: Summary of Geological, Geochemical and Geophysical Studies, Diakow, L.J., Metcalfe, P. and Newell, J.M., Editors, Geological Survey of Canada, Open File and B.C. Ministry of Energy, Mines and Petroleum Resources, Paper 1997-2.

Levson, V.M., Meldrum, D.G., Cook, S.J., Stumpf, A.J., O'Brien, E.K., Churchill, C., Broster, B.E. and Coneys, A.M. (1997): Till Geochemical Studies in the Babine Porphyry Belt: Regional Surveys and Deposit-Scale Studies (NTS 93 L/16, M/1, M/8), *in* Geological Fieldwork 1996, Lefebure, D.V., McMillan, W.J. and McArthur, J.G, Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1997-1, this volume.

MacIntyre, D.G., Webster, I.C.L. and Desjardins P. (1997): Bedrock Geology of the Old Fort Mountain Area (93M/1); in Geological Fieldwork 1996, Lefebure, D.V., McMillan, W.J. and McArthur, J.G, Editors, *B.C. Ministry of Employment and Investment,* Paper 1997-1, this volume.

Plouffe, A. (1994a): Surficial Geology, Chuchi Lake, British Columbia (93N/SE); *Geological Survey of Canada,* Open File 2842 (1:100 000 map).

Plouffe, A. (1994b): Surficial Geology, Tezzeron Lake, British Columbia (93K/NE); *Geological Survey of Canada,* Open File 2846 (1:100 000 map).

Ryder, J.M. and Clague, J.J. (1989): British Columbia Quaternary Stratigraphy and History, Cordilleran Ice Sheet; *in* Quaternary Geology of Canada and Greenland, Fulton, R.J., Editor, *Geological Survey of Canada,* Geology of Canada, Number 1, pages 48-58.

Tipper, H.W. (1971): Glacial Geomorphology and Pleistocene History of Central British Columbia; *Geological Survey of Canada*, Bulletin 196, 89 pages.

Tipper, H.W. (1994): Glacial Geomorphology and Pleistocene History of Central British Columbia; *Geological Survey of Canada*, Bulletin 196, 89 pages.

Wittneben, U. (1981): Terrain Maps for the Hazelton Map Area (NTS 93 M/NW, NE, SE); *B.C. Ministry of Environment, Lands and Parks,* unpublished 1:50,000 scale maps.