SUMMARY OF THE INTERIOR PLATEAU PROGRAM: ACTIVITIES BY THE BRITISH COLUMBIA GEOLOGICAL SURVEY IN THE SOUTHERN NECHAKO PLATEAU (Parts of 93F,C,K)

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KEYWORDS: Southern Nechako Plateau, Interior Plateau, regional geology, surficial geology, mineral deposits, lake sediment geochemistry, till geochemistry.

INTRODUCTION

The Interior Plateau Program is a federal-provincial multidisciplinary geoscience initiative funded under the guidelines of the Mineral Development Agreement. The program, ongoing since 1992, and involving projects by geoscientists from the Geological Survey of Canada and the British Columbia Geological Survey Branch, concluded in 1995. Individual projects are currently in the write-up stage, with final reports to be collated in a volume that is scheduled for publication in March, 1996.

Prospective geological environments for a variety of mineral deposits exist in the Interior Plateau as inferred from some important mines located in the region (Figure 1). However, mineral exploration in this region has generally been hampered by a number of factors, some of which include: inaccessibility, vegetation and glacial cover, and a blanket of Neogene lava flows. Outdated bedrock mapping and lack of surficial mapping, regional gochemistry and modern geophysical coverage were major deficiencies in the geoscience database prior to the start of the Interior Plateau Program. The purpose of this program was to identify mineral potential and promote mineral exploration through improved understanding of the geology of the region. Furthermore, there is a need to develop and evaluate drift exploration models and geochemical exploration techniques applicable to drift-covered plateau regions, and to determine geochemical pathfinder elements and their significant thresholds in tills and lake sediments on the Interior Plateau.

Projects directed by the British Columbia Geological Survey Branch include bedrock and surficial geology mapping at 1:50 000 scale, till and lake sediment geochemistry and mineral deposit investigations (Figures 2 and 3). Most of these scientific studies were fully integrated and conducted in the Nechako Plateau. The exception is in the southern Fraser Plateau, where bedrock mapping along the Coast-Intermontane belt boundary was completed in 1995 (see Schiarizza, 1996; this volume).

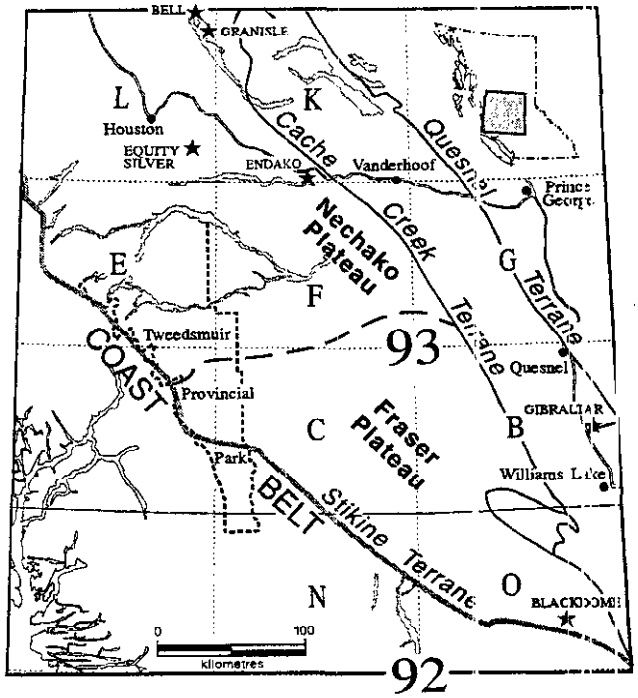


Figure 1. Tectonstratigraphic terranes and physiographic subdivisions in central British Columbia.

The integrated approach of projects in the Nechako area has been highly successful; significantly improving geological understanding and having a profound impact on grassroots mineral exploration. During the 1993 field program, new mineral occurrences such as the Tommy gold prospect was discovered. More than 1300 claim units were staked in 1994; more than ten times the 1993 level, and a 35% increase over 1992. This activity is the direct result of new discoveries and publication of new geoscience data, specifically bedrock, till and regional geochemical maps.

BEDROCK MAPPING

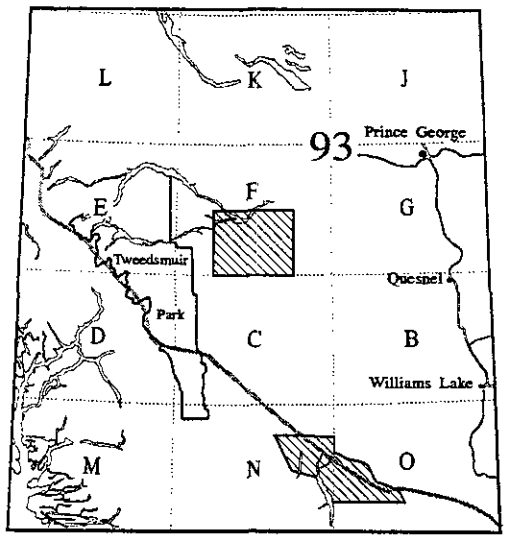
Bedrock mapping at 1:50 000 scale, conducted over three field seasons in the southern Nechako Plateau, has been completed in four mapsheets covering roughly 3500 square kilometres, centred on the Fawnie and Nechako ranges and connected east-west trending ridges of the Entiako Spur and Naglico Hills. These studies include mapping in the Natalkuz Lake (93F/6, Diakow *et al.*, 1993; Green and Diakow, 1993), Fawnie Creek (93F/3, Diakow and Webster, 1994; Diakow *et al.*, 1994), Tsacha Lake (93F/2, Diakow *et al.*, 1995a, b) and Chedakuz Creek (93F/7, Diakow *et al.*, 1995c) map areas.

Objectives of the mapping project were to determine stratigraphic, plutonic and structural relationships, establish a framework of geological events and identify favorable environments to focus exploration for epithermal precious metals and porphyry style mineralization. The main conclusions of this program are summarized here.

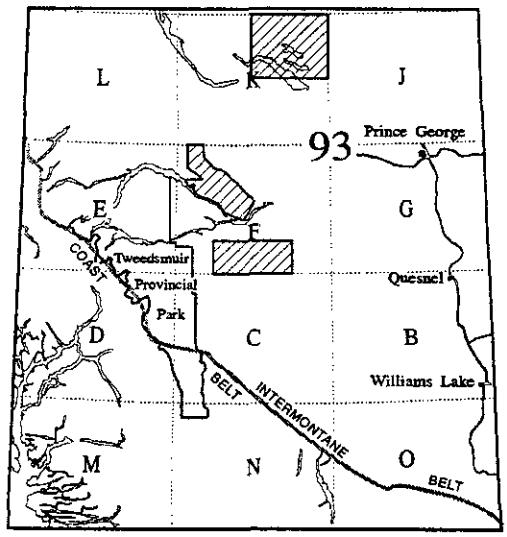
LITHOSTRATIGRAPHY

The southern Nechako Plateau region is underlain by rocks that vary in age from Late Triassic to Neogene. The stratigraphy comprises rare Late Triassic marine sediments at the base, succeeded by two sequences of interlayered volcanic rocks and volcaniclastic sediments containing fossils that range in age from early Toarcian to early Bajocian. Early volcanism (Toarcian and Aalenian?) is exclusively rhyolitic in composition; it contrasts with a younger (Bajocian?), predominately basaltic event. Both sequences record island arc volcanic activity and associated intrabasinal sedimentation. Early Callovian marine siltstone and shale are sporadically exposed. In places, sections feature chert-bearing conglomerate interbeds that become more prevalent eastward from the Fawnie Range towards the Nechako Range. The probable provenance of chert detritus is the Cache Creek Terrane lying immediately to the east. New radiometric dates from areally restricted, unnamed volcanic remnants suggest that subaerial eruptions recurred during Late Jurassic (*ca.* 152 Ma), Jura-Cretaceous (*ca.* 144 Ma) and Late Cretaceous time (*ca.* 65 Ma).

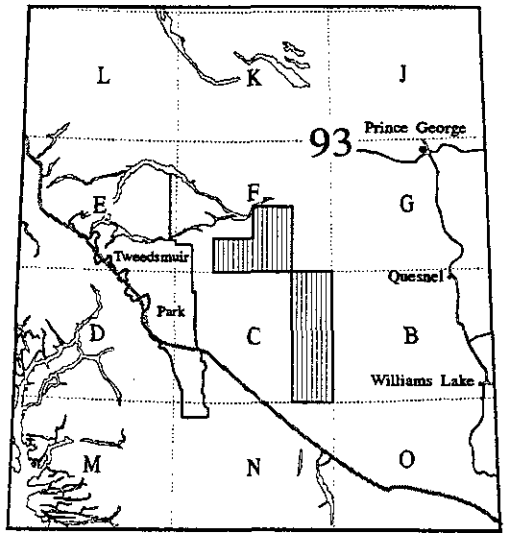
Tectonic uplift of the Fawnie and Nechako ranges preceeded a regional episode of high-potassium calcalkaline volcanism that characterizes Paleogene time. During Middle Eocene time the Ootsa Lake Group, dominated by continental arc rhyolitic and less voluminous andesitic rocks, formed an extensive volcanic field. At present these strata occupy a small area of the uplifted region; however, they are widespread in topographically lower regions to the north and south. In the Fawnie Range these rocks record the growth of flow



Bedrock Mapping



Regional Lake Sediment Geochemistry



Surficial Geology and Till Geochemistry

Figure 2. Location of geoscience projects in the Interior Plateau region.

domes and the development of a relatively small volcanic subsidence structure superposed on older Jurassic plutonic and volcanic rocks. The Endako Group is a sequence of high-potassium andesitic flows that have compositional continuity with volcanic rocks of the Ootsa Lake Group. Their source is believed to be broad volcanic centres that lay to the north of the uplifted region. By Neogene time, alkaline shield volcanoes and probable fissures erupted extensive sheets of basaltic flows assigned to the Chilcotin Group. The Chilcotin Group, restricted to the southern flank of the Nechako and Fawnie ranges, apparently thickens southward toward stratovolcanoes comprising the Anahim volcanic belt.

PLUTONIC EVENTS

The oldest plutonic rocks are small stocks and plugs of augite porphyry that are interpreted as subvolcanic feeders for Middle Jurassic augite phyric basaltic rocks. The Jura-Cretaceous (*ca.* 141 Ma) Capoose batholith underlies much of the western part of the Fawnie Range. The composition of this intrusion is relatively uniform, varying from hornblende-biotite granodiorite to quartz monzonite. Several newly discovered epithermal precious metal prospects are related to hydrothermal activity localised along the margin of the pluton. A single small outcrop of biotite-bearing dacite flows yields a radiometric age (K-Ar, 144 Ma) that is contemporaneous with the Capoose batholith, suggesting that Jura-Cretaceous magmatism may have had an extrusive component, much of which either has been subsequently eroded or is indistinguishable in the field from older volcanic rocks.

Late Cretaceous magmatism is restricted to the northern part of the Fawnie Range where felsic sills and dikes on the Capoose property contain disseminated silver. These hypabyssal intrusions have radiometric ages of 64 to 68 Ma, identical to granodiorite that was dated previously (Andrew, 1988), and mapped in this study as part of the Capoose batholith. New radiometric dates, however, suggest the batholith is significantly older (*ca.* 141 Ma). The discrepancy in ages suggests that the batholith may be a composite body, cut by a younger, compositionally similar pluton that is comagmatic with felsic hypabyssal rocks on the Capoose property. Uranium-lead zircon geochronology is in progress to better define the age of the Capoose batholith. Throughout the Nechako Range, dioritic stocks, sills and dikes cut penetratively cleaved Callovian and older strata. Locally they are weakly mineralized, carrying disseminated copper. Eocene intrusions occur in several widely spaced areas with volcanic rocks of the Ootsa Lake Group. At the Wolf precious metal prospect, an Eocene potassium feldspar megacrystic sill, believed to be comagmatic with felsic extrusive rocks, forms a resistive caprock on the deposit. Quartz feldspar porphyry sills and small plugs occur mainly in the central Fawnie Range, near outliers of the Ootsa Lake Group. The CH pluton has recently determined K-Ar dates on hornblende and biotite of 52 Ma and 49 Ma, respectively; it crops out about 1 kilometre west of porphyry copper showings on the CH property.

STRUCTURE

Mesozoic rocks dominate the Fawnie and Nechako ranges, but they terminate abruptly to the north and south, where topographically subdued terrain is underlain primarily by Eocene and younger volcanic successions. These dramatic changes in physiography and stratigraphy reflect a broad horst, called the Nechako uplift. A series of northeast-trending faults delimit the horst to the north and south, and internally offset stratigraphy as young as Middle Eocene.

The timing of structural uplift is uncertain, but it may be contemporaneous with deformation that imparted a pervasive penetrative cleavage and local mylonitic fabric on Jurassic strata in the Nechako Range. $^{40}Ar/^{39}Ar$ dating of sericite developed on the cleavage planes of probable Aalenian volcanic rocks is suggestive of Late Cretaceous deformation. Undated dioritic plutons and the Eocene CH stock truncate the predominant northwest-trending structural fabric in the Nechako Range.

The Nechako horst may have remained a slightly elevated region for much of Tertiary time. The distribution and thickness of Eocene and younger volcanic units diminishes over the horst, relative to extensive volcanic fields to the north and south. In the uplifted region Eocene strata are restricted to several outliers that rest upon Middle Jurassic rocks. Block faults, accompanied locally by caldera subsidence and the emplacement of hypabyssal and epizonal plutons, all emphasize the extensional regime that characterized the Nechako uplift during Eocene time.

MINERAL DEPOSIT STUDIES

Twenty metallic mineral occurrences ranging from newly discovered showings to developed prospects, were studied in parts of the Nechako (NTS 93F) and Anahim (NTS 93C) map areas (Figure 3). Each occurrence was characterized in terms of geologic setting, structural controls, style of mineralization, ore mineralogy and alteration assemblage. The Holy Cross and Wolf occurrences were mapped at 1:10 000 scale, and a map of the former published (Lane, 1995). Descriptions of most other mineral occurrences have also been published (Lane and Schroeter, 1995; Schroeter and Lane, 1992, 1994). At present, K-Ar and U-Pb geochronology and trace lead analysis for specific deposits are in progress at the University of British Columbia.

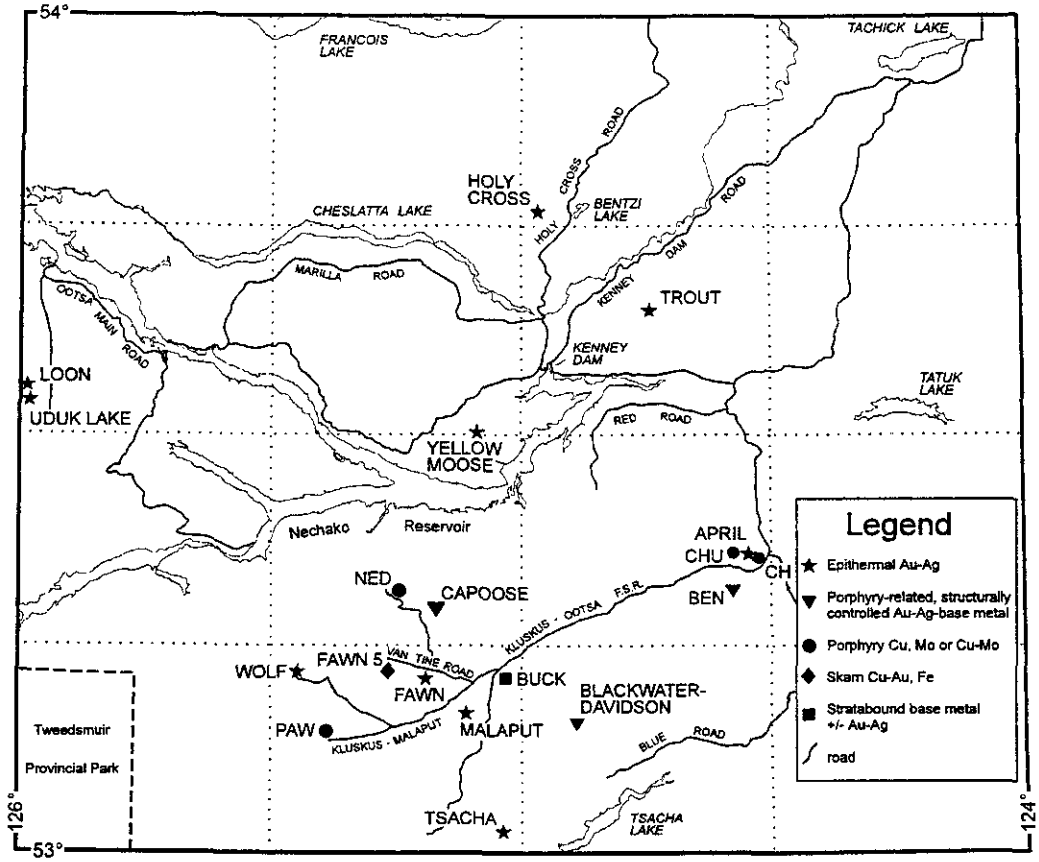


Figure 3. Location of metallic mineral occurrences investigated in the southern Nechako Plateau.

Mineral occurrences appear to be associated with three magmatic episodes: Eocene (*ca.* 50 Ma) and Late Cretaceous (*ca.* 65 Ma.) felsic volcanism and plutonism and Jura-Cretaceous calcalkaline intrusive activity (*ca.* 141 Ma.). Eocene mineral occurrences consist of:

- low-sulphidation, adularia-sericite epithermal gold-silver quartz vein systems related to northerly trending structures and rhyolitic volcanic activity that characterizes the Ootsa Lake Group throughout much of the Nechako area. Such occurrences have bonanza vein and bulk-tonnage potential; examples include the Wolf, Clisbako and Holy Cross prospects.
- Porphyry copper and/or molybdenum prospects in Jurassic country rocks are spatially associated with Eocene granodiorite of the CH stock.

Older deposits are associated with probable Late Cretaceous or older (?) subvolcanic rhyolitic intrusions carrying disseminated and fracture-controlled silver-gold-zinc mineralization at the Capoose prospect or within thermally altered and hornfelsed Middle Jurassic volcanic rocks marginal to the Jura-Cretaceous Capoose batholith. Notable examples include porphyry molybdenum-copper occurrences (Ned); iron and copper-gold skarn (Fawn 5) and, gold and silver-bearing epithermal quartz-vein stockworks (Tsacha).

LAKE SEDIMENT GEOCHEMISTRY STUDIES

A variety of lake sediment geochemistry studies were conducted in the Nechako Plateau region between 1992 and 1995 (Cook, 1993, 1995; Cook and Jackaman, 1994a, b; Cook and Luscombe, 1995; Cook *et al.*, 1994, 1995). The lake sediment geochemistry program had two major components: (1) detailed case studies of individual lakes, to provide a better understanding of how sediment geochemistry reflects the presence of adjacent mineral deposits, and (2) regional geochemical surveys, to provide baseline data for mineral exploration and environmental studies.

LAKE SEDIMENT CASE STUDIES

Case studies were completed at 25 lakes in 18 localities. The main objective was to determine the effectiveness of lake sediments as a sample medium for future regional geochemical surveys. A secondary objective was to determine their usefulness in more advanced, property-scale stages of geochemical exploration, by characterizing metal distribution patterns

in different types of lake sediments typically found in the area. The main conclusions are as follows:

- Metal concentrations in lake sediment reflect the presence of adjacent epithermal gold and porphyry copper or molybdenum mineralization in each of seven case studies. Specifically, centre-lake gold concentrations of 4 ppb or greater, and molybdenum concentrations of 12 ppm or greater at these sites reflected the presence of epithermal and porphyry prospects, respectively.
- Considerable within-lake geochemical variations occur between individual sub-basins of the same lake, and between near-shore and profundal sediment within sub-basins.
- In the case of gold, centre-lake sediments may, but do not necessarily, contain the highest gold concentrations present in the surveyed lakes. Greater gold concentrations may occur in near-shore organic-rich sediments, particularly near drainage in-flows. Gold distribution patterns in the sediment may reveal the locations of stream water and ground water in-flows draining upstream or upslope mineralized bedrock, or its dispersed remnants within till or colluvium.
- Different types of lakes (seepage and drainage) with anomalous sediment geochemistry may require different follow-up exploration strategies. At a minimum, follow-up sampling of any lake sediment anomaly should involve resampling of the original site and verification of the analytical result. However, the data suggest that drainage lakes, which lose water by stream flow through an outlet, are more likely to show near-shore zonation patterns than the generally smaller and more geochemically homogenous seepage lakes, which lack stream in-flows or out-flows. Detailed sampling of anomalous drainage lakes may be an effective tool to map out potential metal zonation patterns and to determine the general direction toward any covered mineral occurrences within a watershed.

REGIONAL LAKE SEDIMENT GEOCHEMISTRY SURVEYS

Much of the Nechako Plateau region, with its subdued topography and abundance of lakes, is better suited for regional lake sediment than stream sediment geochemical surveys. Prior to the beginning of the Interior Plateau Program large tracts of the Nechako and Fraser plateaus lacked regional lake sediment geochemical coverage, and available RGS data were restricted to the eastern parts of the Whitesail Lake (NTS 93E-RGS 16) and Smithers (NTS 93L-RGS 17) map areas.

Three small regional lake sediment geochemical surveys were completed in the Nechako (NTS 93F) and Fort St. James (NTS 93K- results not yet released) areas between 1993 and 1995. They cover an area of about 7300 square kilometres at an average sampling density of about 1 site per 8.3 square kilometres. Objectives of this program are to provide baseline geochemical data necessary for both grassroots mineral exploration and for environmental studies. Geochemical patterns corroborate earlier lake sediment anomalies (e.g., Wolf prospect), enlarge target areas around currently known deposits, and outline new prospective areas (e.g., Tsacha prospect). Significantly, regional lake sediment geochemistry results highlight the epithermal precious metal potential of Jurassic, as well as Eocene, volcanic units. Furthermore, the locations of all five precious and base-metal prospects recorded in the MINFILE database in the Fawnie Creek map area (NTS 93F/3), and located near lakes, were reflected by elevated metal concentrations greater than the 95th percentile of the regional data set.

Implementation of the regional surveys was guided by the results of prior orientation case studies. The following guidelines are useful for conducting regional geochemical surveys in the Nechako Plateau:

- Centre-basin sediment is most suitable for regional surveys, due to its greater homogeneity and higher proportion of fine-grained organic material relative to near-shore sediment.
- Lake sediment geochemical surveys are most effective in this area if every lake in the survey area is sampled, rather than sampling only a selection of lakes at a fixed site density.
- Sampling designs must accomodate the geochemical variation which may be present between separate sub-basins of any one lake. Collection of a single centre-basin sample is sufficient for ponds and smaller lakes, but additional samples should also be obtained from the centres of any major sub-basins.
- There are no simple guidelines for metal signatures in anomalous lakes adjacent to epithermal prospects. Sediment geochemistry in anomalous lakes is related to the geochemistry of the mineralized system, and sediments may, but do not necessarily exhibit multi-element geochemical signatures. Metal signatures range from multi-element (gold-silver-arsenic-molybdenum-zinc) at the Wolf prospect, to single element (gold) at the Tsacha prospect.

SURFICIAL GEOLOGY MAPPING AND REGIONAL TILL GEOCHEMISTRY

Regional till geochemical surveys and 1:50 000-scale surficial geology mapping were conducted to aid mineral exploration in areas of thick glacial drift. Stratigraphic and sedimentologic studies of Quaternary deposits were also completed in order to define the glacial history and help in interpreting till geochemical data. The main objectives of the program were to map the

distribution of Quaternary deposits, decipher the glacial history, identify geochemically anomalous areas, refine models of glacial dispersal and develop methods of drift exploration applicable to the Interior Plateau.

A number of publications relating to this program have been released, including surficial geology and till geochemistry data for the Fawnie Creek map area (NTS 93F/3), Giles and Levson (1994a,b), Levson and Giles (1994) and Levson *et al.* (1994). Recent surficial geology data are available for the Chilanko Forks - Chezacut map areas (93C/1 and 8, respectively), Giles and Kerr (1993), Kerr and Giles (1993a,b); the Clusko River - Toil Mountain map areas (93C/9 and 16, respectively), Proudfoot (1993), Proudfoot and Allison, (1993a,b); the Tsacha Lake - Chedakuz Creek map areas (93F/2 and 7, respectively), Giles and Levson (1995), Giles *et al.* (1995), Weary *et al.* (1995); and Fulton Lake - Old Fort Mountain map areas (93L/16 and 93M/1, respectively), Huntley *et al.*, (1996, this volume). Detailed investigations around areas of known mineralization have also been conducted as part of this program (Levson and Giles, 1995; O'Brien *et al.*, 1995; Stumpf *et al.* (1996, this volume).

RESULTS

Results of Quaternary geology studies indicate that glacial dispersal processes in the region are dominated by the last (Late Wisconsinan) glaciation. In most areas there was one dominant ice-flow direction, influenced by topography during both early and late stages of the Late Wisconsinan (*e.g.,* Levson and Giles, 1994; Levson *et al.*, 1994). Morainal sediments are widespread in the Interior Plateau region; they form a cover, varying in thickness from a few metres to several tens of metres in low-lying areas, to less than 2 metres in upland regions. Glaciofluvial sediments are also common, occurring 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. Glaciolacustrine sediments are common in some valleys, generally at elevations below 750 to 950 metres, often near modern lakes. Stratigraphic studies of Quaternary deposits indicate ice damming during both advance and retreat stages of the last glaciation.

Geochemical anomalies associated with glacial dispersal of mineralized bedrock in the region are up to a few kilometres long and several hundred metres or more wide, but some anomalies cover much larger areas (Levson and Giles, 1995). Erratics trains are typically up to several kilometres long and more readily detected than till anomalies. Both erratics trains and geochemical anomalies in till show a pronounced elongation parallel to ice-flow direction. In areas of thick till, near-surface anomalies may be displaced by 500 metres or more down-ice from their bedrock source. As the till geochemistry reflects up-ice bedrock sources and not the immediately underlying bedrock, subsurface exploration targets should be up-ice, rather than at the head of the anomaly.

Basal till sampling is an effective tool for regional exploration programs in drift-covered parts of the Interior Plateau (Levson *et al,* 1994, Cook *et al.,* 1995; Kerr and Levson, 1995). To reflect mechanical dispersal processes, samples should be collected from the C soil horizon. For property-scale exploration programs, where sediment types other than basal tills may be sampled, sedimentologic data should be collected at all sample sites in order to distinguish till from glacigenic debris-flow, colluvial, 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. Similarly, an understanding of ice-flow history, glacial dispersal processes, transportation distances and Quaternary stratigraphy are considered essential for successful drift exploration programs in this region.

INTEGRATED GEOLOGICAL STUDIES

An important focus of the Interior Plateau Program has been the integration of geological studies from a number of different disciplines. One of the first products of these multidisciplinary studies was the production of a combined bedrock and surficial geology map of the Fawnie Creek map area (Diakow *et al.,* 1994). This was the first map of this type produced by the B.C. Geological Survey Branch in many years and, due to the positive reception it received from mineral exploration companies working in the region, two more maps of this type were produced after the 1994 field season (Diakow *et al.,* 1995b,c). Other integrated studies include: a detailed comparison of geochemical results from till and lake sediment surveys conducted in the Fawnie Creek map area (Cook *et al.,* 1995), the identification of several new exploration targets in the same area using data from bedrock geology as well as till and lake sediment geochemical studies (Diakow *et al.,* 1994; Cook *et al.,* 1994; Levson *et al.,* 1994) and an electromagnetic survey conducted to help delineate the margins of the Capoose batholith and till thickness in areas with anomalous till geochemistry (Best *et al.,* in press). Further interdisciplinary work is planned for the Nechako Plateau during the Nechako NATMAP program and may lead to the identification of other areas with high mineral potential as well as the development of exploration techniques specifically suited to this part of British Columbia.

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