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DRIFT EXPLORATION STUDIES, VALLEY COPPER PIT, HIGHLAND VALLEY COPPER MINE, BRITISH COLUMBIA: STRATIGRAPHY AND SEDIMENTOLOGY (92I/6, 7, 10 and 11)

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INTRODUCTION

During the 1992 field season, drift exploration studies were undertaken by staff of the British Columbia Geological Survey Branch at the Highland Valley Copper mine (Figure 4-4-1). The project is part of a drift-prospecting program integrating surficial geology and applied geochemistry in the search for mineral deposits in areas of glaciated and drift-covered terrain in the province. Related studies this year include a case study documenting geochemical dispersion in till, conducted at the Galaxy deposit south of Kamloops, and the Anahim Lake map sheet, where reconnaissance till geochemical data were collected and terrain maps were produced (Proudfoot, 1993; Giles and Kerr, 1993; both this volume). The objectives of the program are summarized as follows:

- Develop, evaluate and recommend methods and techniques applicable to mineral exploration.
- Stimulate mineral exploration activities in glaciated and drift-covered regions of the province through specialized surficial geology techniques.
- Develop interpretive drift-exploration models founded on principles of Quaternary geology.
- Produce surficial geology and applied derivative maps at a scale of 1:50 000 which will be of practical use to the exploration community.

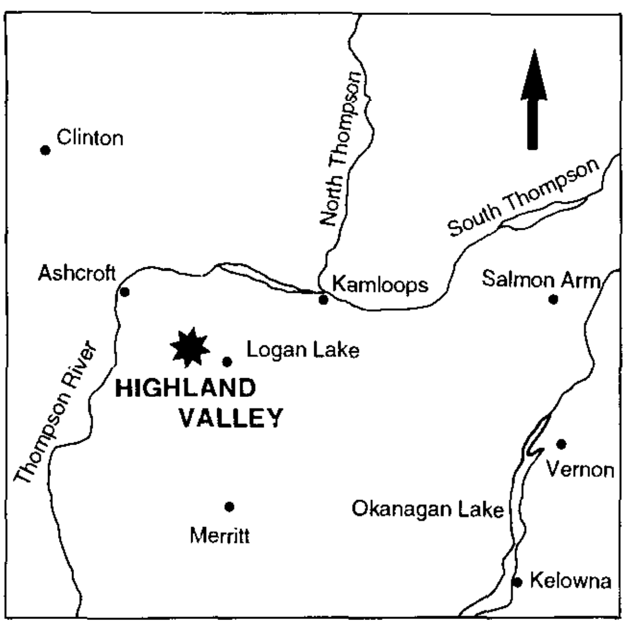

Figure 4-4-1. Location of the Highland Valley study area, southern British Columbia.

Previous studies relevant to the general drift-exploration program and its objectives have been detailed or summarized elsewhere (*e.g.*, Kerr and Bobrowsky, 1991; Sibbick *et al.*, 1992). The present report provides a summary of field activities and details of the stratigraphy and sedimentology in the Valley pit area of Highland Valley Copper mine located some 370 kilometres northeast of Vancouver. Detailed interpretive results of the ancillary geochemical and surficial data will appear elsewhere, following completion of several analytical procedures now in progress.

Highland Valley Copper mine was selected for investigation during this field season given:

- Easy access to a lengthy and complex overburden sequence which overlies strongly mineralized bedrock (as recently exposed by mining in the Valley pit).
- The fortuitous occurrence of organic materials scattered throughout the deposits, which are suitable for radiocarbon dating and thus chronological control.
- The opportunity to evaluate modern methods of lake-sediment geochemistry sampling by analogy to an ancient lake sediment sequence (in direct contact with the mineralized bedrock).
- The possibility of obtaining proxy Quaternary data through paleomagnetic and pollen analyses.
- The occurrence of economic mineral deposits in the region.

A detailed study of the geology and geochemistry of a preserved lake sediment sequence overlying the Valley Copper orebody was undertaken, as a complement to the Applied Geochemistry Unit's lake sediment program (Cook, 1993, this volume). The goal of this research is to define controls on metal transport and deposition in a drained lake directly overlying ore. The results of these investigations will provide us with information (*i.e.*, geochemical dispersion characteristics) for evaluating the viability of modern lake sediment geochemistry. The underlying premise of modern lake sediment sampling assumes that these samples provide regional geochemical data representative of the underlying lithologies and reliable indications of local mineral occurrences. The occurrence of ancient lake sediments in direct contact with a known orebody provides a standard against which methods of modern lake sediment sampling can be compared. The success of this investigation depends to a large extent on the detail and accuracy of interpretation provided by complementary stratigraphic and sedimentological research. The present paper describes this research work.

PREVIOUS WORK

Excluding the work of early geologic explorers working in the Interior Plateau of southern British Columbia, it is the notable mineral deposits in the area (including Bethlehem, Lornex, Valley Copper, Highmont and JA; Figure 4-4-2) which have significantly influenced ongoing geological and mineral exploration studies. These studies have added immensely to the geological database.

Previous studies on the bedrock geology of the Highland Valley deposits and surrounding area have been detailed in several publications (*cf.* Sutherland Brown, 1976 for review articles as well as discussion below). Previous surficial studies are, however, less well known. During the 1960s and 1970s, R.J. Fulton (Geological Survey of Canada) mapped the surficial sediments directly east of the study site and developed a good understanding of the regional patterns of glaciation and deglaciation for the southern Interior Plateau. Based on his work (Fulton, 1969, 1975; Fulton and Smith, 1978), the Quaternary stratigraphy for this region can be summarized as typically consisting of Okanagan Centre Drift deposits (type locality near Okanagan Lake) of Early Wisconsinan age (>65 000 years old), overlain by Bessette Sediments (type locality near Lumby) of mid-Wisconsinan age (>20 000 - 65 000 years old) and Kamloops Lake Drift deposits (type locality near Kamloops Lake) correlative with the Late Wisconsinan (10 000 to 20 000 years old). Much older sediments, including deposits with reversed polarity (Matuyama age; >790 000 years), have recently been identified south of Merritt (Fulton *et al.*, 1992). Stratigraphy in the Merritt area (Table 4-4-1) is better understood and, therefore, much more detailed than elsewhere, but the essential components remain similar to the generalized stratigraphy of the Interior Plateau.

Perhaps the greatest attention has been paid to the history of deglaciation of the southern Interior Plateau and surficial deposits associated with the event (Fulton, 1967, 1969,

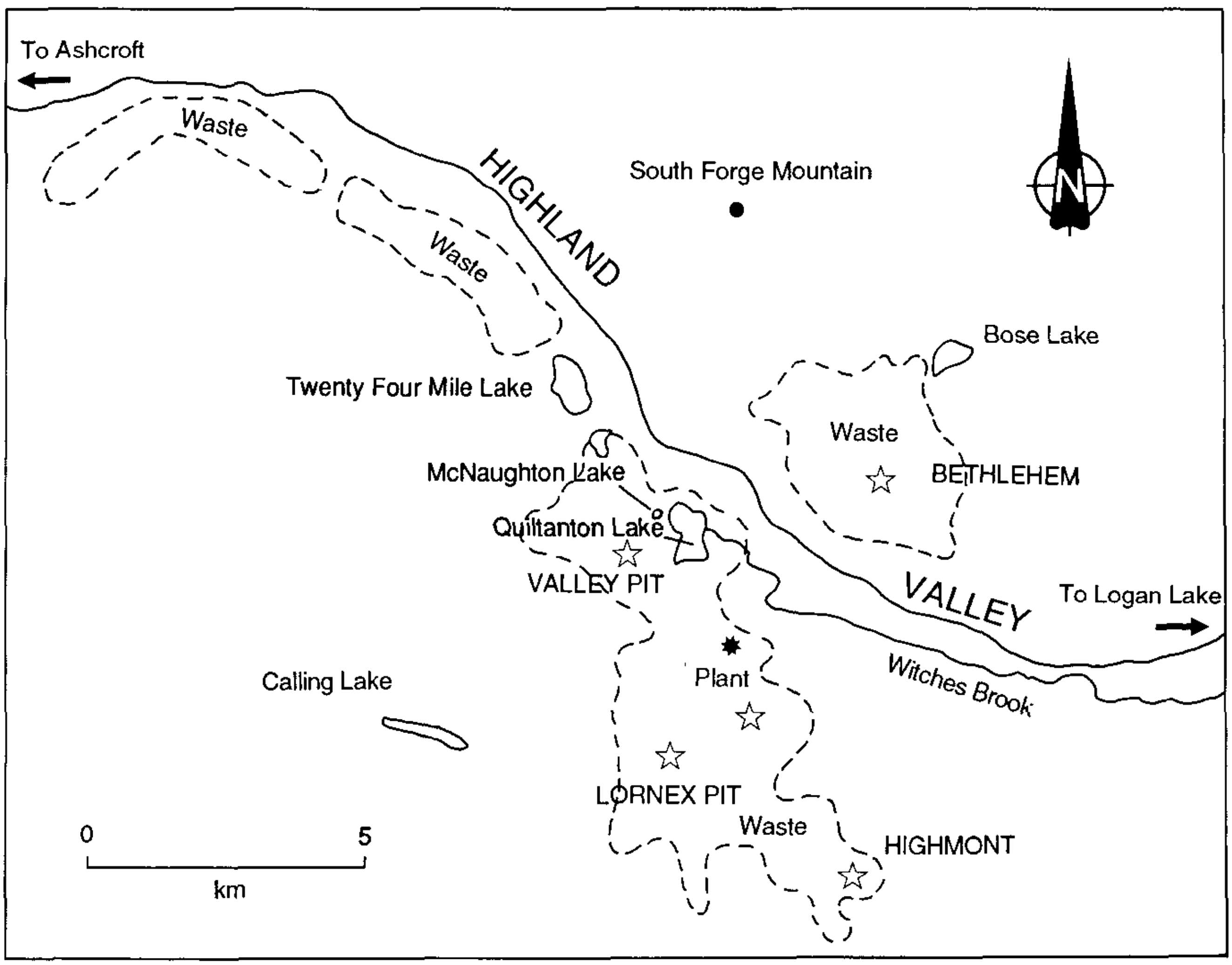

Figure 4-4-2. Location of the Valley pit and other deposits and features referred to in the text.

TABLE 4-4-1
QUATERNARY STRATIGRAPHIC UNITS IN THE VICINITY OF MERRIT, BRITISH COLUMBIA

UNIT NAME	LOCALITY	INTERPRETATION	AGE
Merritt silts (Kamloops Lake Drift)	Merritt, Lily Lake Road, *Coldwater*	Glacial lake sediments	±11 ka
Till (Kamloops Lake Drift)	Lily Lake Road, Coldwater	Glacial deposit	11-20 ka
Proglacial Sediments (Kamloops Lake Drift)	Lily Lake Road	Proglacial deposits	±20-25 ka
Brown Drift	Coldwater River	Glacial deposits	> 25 to < 790 ka
Valley basalts	Chutter Ranch, Quilchena Creek valley	Volcanic eruption	100 to < 790 ka
Coutlee sediments	Lily Lake Road	Interglacial basin fill deposits	≥790 ka
Sub-Coutlee sediments	Lily Lake Road	Glacial lake deposits	> 790 ka
Coldwater silts	Coldwater	Glacial lake deposits	> 790 ka

According to Fulton et al. (1992)
Age is given in thousands of years before present (ka)

1991; Church and Ryder, 1972). The present day physiography, characterized by rolling uplands, steep-walled, flat-floored valleys, as well as open grassland and pine forested slopes, is strongly influenced by the style of deglaciation. Most of the major valleys and tributaries in the Interior Plateau supported large ice-dammed lakes as ice retreated northward at the end of the Pleistocene (Ryder *et al.*, 1991). These glaciolacustrine deposits typically consist of sand and silt, are of varying thickness and pose considerable hazard to transportation corridors and structures given their propensity to slope failure (Evans and Buchanan, 1976). From an exploration perspective the pervasive glaciolacustrine sediments conceal mineral deposits. As noted elsewhere in this paper, glaciolacustrine deposits are an integral component of stratigraphy of the valley-fill sequences of the study area and must be adequately understood.

At Highland Valley Copper, an early Quaternary geological investigation by J. Mollard (Ripley, Klohn and Leonoff, 1972) included air photo study and surficial map generation (scale of 1:31 680) as well as an interpretation of borehole drilling results from Witches Brook, east of the present mine area (Figure 4-4-2). More recently, Golder Associates Ltd. (1992) drilled a 245-metre hole in the valley floor north of the Highland Valley Copper mine. One other recent surficial study completed near the mine area is that of Clague (1988) who examined tephra and organic remains exposed in sediments of McNaughton Lake which was drained and trenched in early 1985 to allow for mine expansion (Figure 4-4-2).

BEDROCK GEOLOGY

The Valley orebody is located in the central core of the Late Triassic Guichon Creek batholith. The multiphase intrusions within the batholith are progressively younger from the border to the core. The core, or Bethsaida phase, is a coarse porphyritic granodiorite (Figure 4-4-3). The main alteration types are argillic, potassic and sericitic. The copper sulphides are bornite and chalcopyrite. In the central part of the orebody bornite:chalcopyrite ratios are 3:1 and decrease away from the core to the fringes. Bornite and

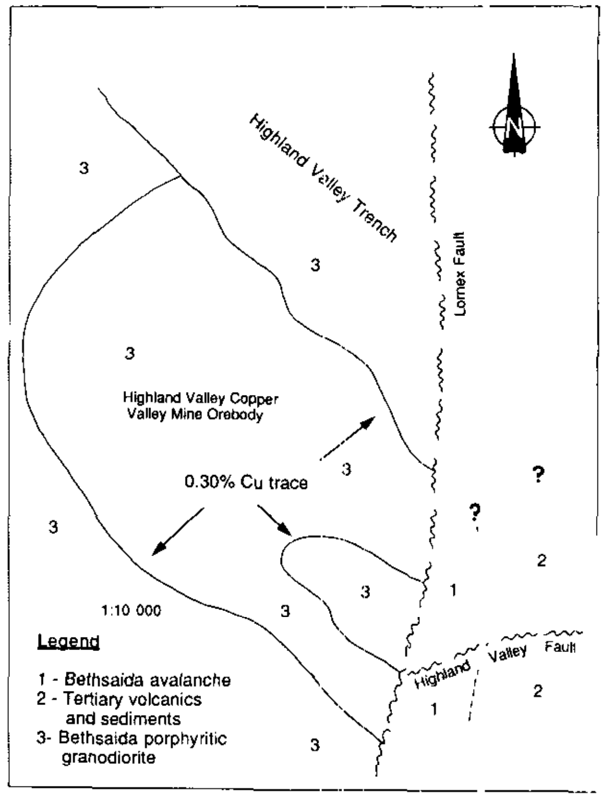

Figure 4-4-3. Bedrock geology of the Valley pit area. *See* text for details.

chalcopyrite are associated with a stockwork of quartz-sericite and crystalline sericite veins. The fracture sets are related to the north-striking Lornex fault and the east-striking Highland Valley fault. The southeast extension of the orebody is terminated by the Lornex fault. Drilling data indicate that the Lornex fault formed a 70° to 80° escarpment facing east with a height of at least 280 metres. Erosion and subsequent "bedrock avalanching" along the escarpment deposited ore-bearing boulders and debris on exposed Tertiary volcanics which are down-faulted against the Bethsaida phase. Glaciation and general erosion have modified the escarpment (*cf.* McMillan, 1976; Waldner *et al.*, 1976; Osatenko and Jones, 1976).

METHODS

Surficial data and geochemical samples were collected at the western margin of the Valley open pit (Figure 4-4-2). Ongoing mining in this area provides access to both mineralized bedrock outcrop and deep valley-fill sediments. Mining procedures provided ready access to exposures of unconsolidated sediments including the deepest deposits which are directly in contact with underlying mineralized outcrop. Each mining bench is exactly 12.5 metres above the underlying bench, thereby providing accurate positioning and elevation data for the study. The benches also provide steep faces accessible for detailed stratigraphic and sedimentologic analysis (Table 4-4-2). During this summer, the east wall of the pit provided the best exposure of unconsolidated sediments, including evidence of the rela-

TABLE 4-4-2
FREQUENCY DISTRIBUTION OF DRIFT EXPLORATION DATA

FACE	ELEVATION	LITHO.	PEBBLE	TEXTURE	GEOCHEM	POLLEN	14C	FABRIC
13	1250.0-1262.5	VII	1	1	-	-	-	1
12	1237.5-1250.0	VII	-	-	-	-	-	-
11	1225.0-1237.5	VI, VII	1	1	-	-	-	1
10	1212.5-1225.0	VI	1	1	-	-	-	1
09	1200.0-1212.5	VI(VIII,IX)	4	1	(20)	-	-	1
08	1187.5-1200.0	IV,V(VIII)	-	1	-	1	1	-
07	1175.0-1187.5	IV	1	-	-	-	-	1
06	1162.5-1175.0	IV	1	-	-	-	-	-
05	1150.0-1162.5	IV	1	-	-	-	-	1
04	1137.5-1150.0	III, IV	2	1	-	2	4	-
03	1125.0-1137.5	II, III	-	-	41	3	1	-
02	1112.5-1125.0	II	-	-	34	-	4	-
01	1100.0-1112.5	I, II	3	2	21	3	1	1

In relation to exposure face, elevation (metres above sea level), lithostratigraphic unit and type of sample information for the Highland Valley Copper mine study. Note: Holocene lake sediments (lithostratigraphic unit IX) and underlying outwash deposits (lithostratigraphic unit VIII) which have cross-cut older deposits at a lower elevation are listed in brackets.

tionship of the lowest sediments to the mineralized bedrock. Excavation depth had reached 1100 metres above sea level, which provided access to a total of 13 faces for a cumulative vertical exposure of 162.5 metres.

Surficial studies included detailed descriptions of the nature and extent of the major lithostratigraphic units and beds exposed in the pit faces. Characteristics described include types of contacts, lateral and vertical extent of units and beds, internal structures and bedding style, sediment texture, as well as clast lithologies, shape, size and fabric. Bulk samples were taken from major units and unique beds for textural analysis. Similarly, palynological samples were taken from nonglacial deposits for relative dating and paleoecological analysis. Samples of wood were collected for conventional ^{14}C analysis. Pebble samples (100 clasts/sample) were taken from representative units and beds for lithologic analysis. Sample provenance relative to pit face, elevation and lithostratigraphic unit is summarized in Table 4-4-2. Palynological, textural, paleomagnetic and radiocarbon samples have been submitted for analysis.

Geochemical sampling was primarily directed toward exposures of the oldest lacustrine sediments. Ninety-six bulk samples (2 to 3 kg) were taken from six profiles exposed on the eastern face of the 1100, 1112.5 and 1125-metre benches (*cf.* Table 4-4-2; Figure 4-4-4). Samples were taken at 1-metre intervals depending on access and exposure. Fifteen additional samples were taken at 10-metre intervals along a well-defined horizon within the lowest sequence in order to study lateral variation in lake sediments. These samples have been sieved to $-250+125$ micron, $-125+63$ micron and -63 micron size fractions for analysis by inductively coupled plasma (ICP) and instrumental neutron activation (INA) analysis. The -63-micron fraction will also undergo a sequential partial extraction procedure to identify the residence sites of copper and other metals within the silty clay fraction. Representative sampling of the modern lake sediments (Quiltanton Lake) was also undertaken. A total of 20 bulk samples were obtained from various horizons in the calcareous peat and marl-dominated modern rhythmites (Table 4-4-2). These samples are now in process.

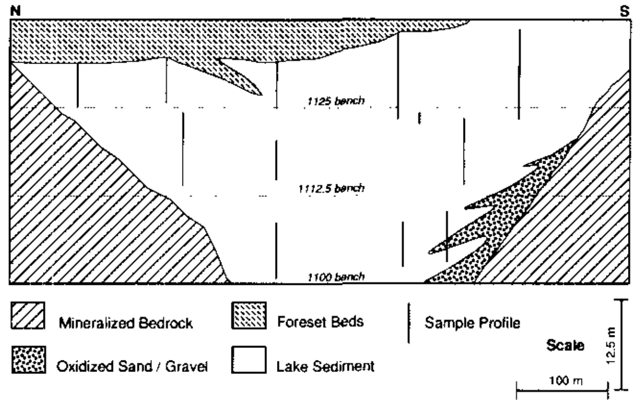

Figure 4-4-4. Schematic view of Valley pit illustrating location and relationship of geochemical profiles in lithostratigraphic Unit II.

RESULTS

Stratigraphy and Sedimentology

Mapping of the unconsolidated sediments in the Valley pit and surrounding area resulted in the identification of nine lithostratigraphic units (Figure 4-4-5). Bearing in mind the borehole data discussed earlier, the valley-fill sediments probably extend to a greater depth than that described in this report (most likely an additional 100 metres or more) which is limited to pit excavation depth.

UNIT I

The oldest exposed lithostratigraphic unit in the pit area directly overlies the mineralized granodiorite and averages 6 to 10 metres in thickness (Plate 4-4-1). This unit is characterized by poorly sorted, alternating beds of strongly oxidized, silty sand and sandy gravel. Oxidation lines crosscut the natural bedding planes. All beds dip steeply toward the valley floor. Most clasts are strongly weathered, subrounded to subangular and of local provenance, the basal part includes a grus. Occasional rip-up clasts of laminated silty clay beds are interspersed in the lower part of the unit. An unoxidized, discontinuous, gravel-supported diamicton with a silty sand matrix, 30 to 150 centimetres thick, and containing both local and exotic unstriated clasts, occurs at the base of the unit in one part of the pit. Sand and gravel beds in the upper part of the unit interfinger with rhythmites and therefore grade into the overlying unit over a short distance (~1 m). The sediments in this unit are interpreted to represent *in situ* bedrock weathering, colluviated bedrock, sand with organics and fluvial fan deposits which typically form on steeply inclined slopes of deep valleys.

UNIT II

Unit II (35 m) consists of an intercalated rhythmite assemblage of silty clay and clayey silt laminae and beds, ranging in thickness from less than 0.1 to 15 centimetres (Plate 4-4-2). Individual rhythmites are primarily horizontally stratified, show graded bedding and sharp, planar contacts. The lowest rhythmites drape over bedrock and

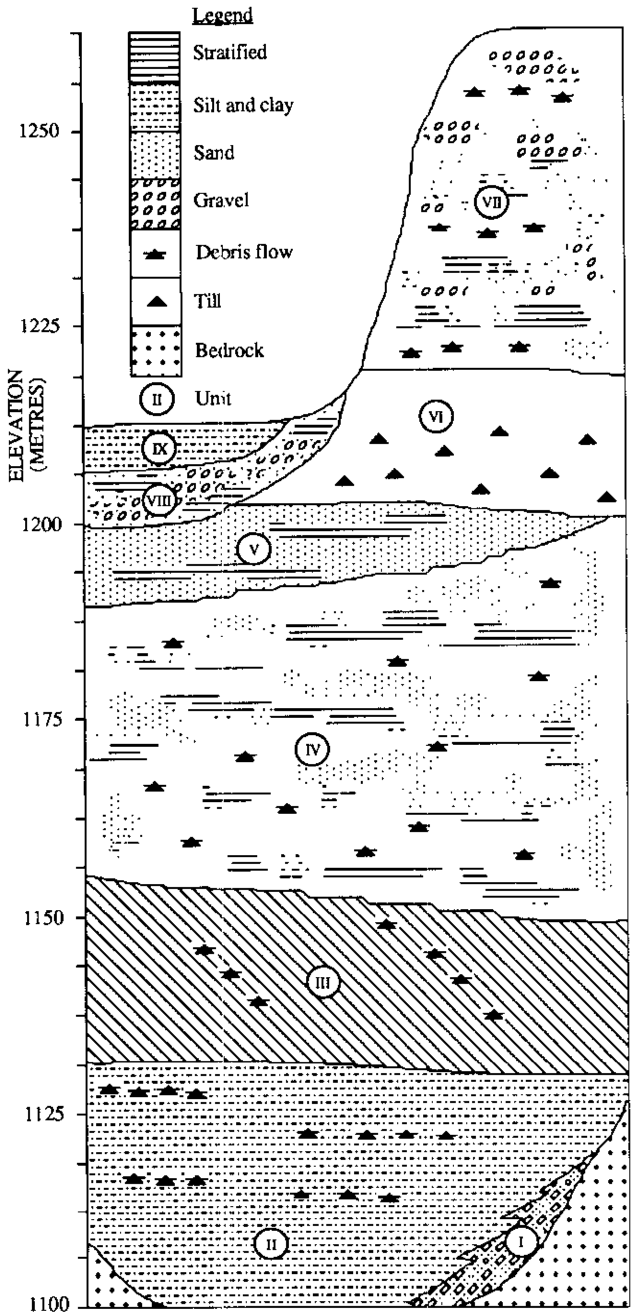

Figure 4-4-5. Composite stratigraphic column of Quaternary sediments from the Valley pit, Highland Valley Copper mine, B.C. See text for details regarding lithostratigraphic units.

deposits of Unit I. Rhythmites become progressively coarser and thicker up section. Localized examples of Type B climbing ripples were observed in one location supporting sandy silt bed sets 5 centimetres thick dipping towards 120°. Rare dropstones with drape laminations and minor penetrative structures are also present. Laterally discontinuous interbeds of massive, matrix-supported and clast-supported diamicton are evident and increase in thickness and frequency towards the top in the unit. Diamictons range from 1 to 35 centimetres in thickness, although one bed 1.1 metres thick was observed. A pebble fabric sample from one of the diamicton lenses has a trend of 169.3° and plunge of 07.3° (S1=0.546). Charcoal fragments and fine organics are conspicuous throughout the unit. Along the southern margin of the pit, rhythmites grade into marl which preserved a paleosol (A-horizon) at three locations. The basal contact is gradational over a distance of approximately 1 metre as estimated from intertongues of rhythmite and sand and gravel beds. This unit is interpreted to represent glaciolacustrine sediments of a proglacial lake environment (*cf.* Ashley, 1988).

UNIT III

Unit III consists of steeply inclined, alternating planar crossbeds of sand and sandy gravel (Plate 4-4-3) and is up to 25 metres thick. Beds dip at angles averaging 25° to 38° toward 145° to 180° on the northeast side of the pit and toward 25° to 60° on the southeast side of the pit. Matrix-supported beds of gravelly sand are mainly medium to coarse sand with minor percentages of pebbles scattered along internal bedding planes. Clast-supported beds of sandy gravel consist mainly of granule to small pebble-sized clasts with a medium to coarse sand matrix. Rarer clast-supported beds with cobbles and boulders supporting an open-work structure are also evident. All types of beds average 60 centimetres in thickness and all show internal fining-upwards sequences (Plate 4-4-4). Very rare occurrences of silty clay and clayey silt laminae, rich in organic detritus including wood, are intercalated with the coarser beds. Rare boulder-sized dropstones and discontinuous beds of diamicton are present and increase in frequency in the upper part of the unit. Fine grained near the base, individual beds become progressively coarser, upwards through the unit. Minor normal faulting and occasional rip-up clasts of laminated clay and silt blocks (up to 20 cm in diameter) are present near the base. At one location, evidence for local glaciotectonic deformation was observed. The steeply inclined beds change to a curvilinear form at their base, resulting in low-angle tangential contacts with the underlying sediments. The basal contact is, therefore, gradational over a few tens of centimetres with the rhythmically laminated sediments of Unit II. This unit is interpreted to represent a foreset bed complex formed by a series of prograding coalescing delta fronts (*cf.* McPherson *et al.*, 1987).

UNIT IV

Unit IV consists of up to 55 metres of poorly sorted sand and gravel beds interbedded with poorly stratified matrix and clast-supported diamicton (Plate 4-4-5). Silty sand beds alternate with sandy gravel lenses, both extremes showing variable contacts, gradation and sorting. Gravel-dominated beds up to 2 metres thick are rare, most beds and lenses are less than 1 metre thick. Occasional dropstones, up to 17 centimetres in diameter, are present in the sandy layers. Contacts between sand and gravel beds and diamicton beds are irregular, wavy and sharp. One matrix-supported diamicton bed is up to 15 metres thick, predominantly comprising a silty sand matrix (Face 5). This particular bed had a pebble fabric sample trending 183.1° and plunging 11.2° (S1=0.560). A thinner diamicton bed higher (Face 7)

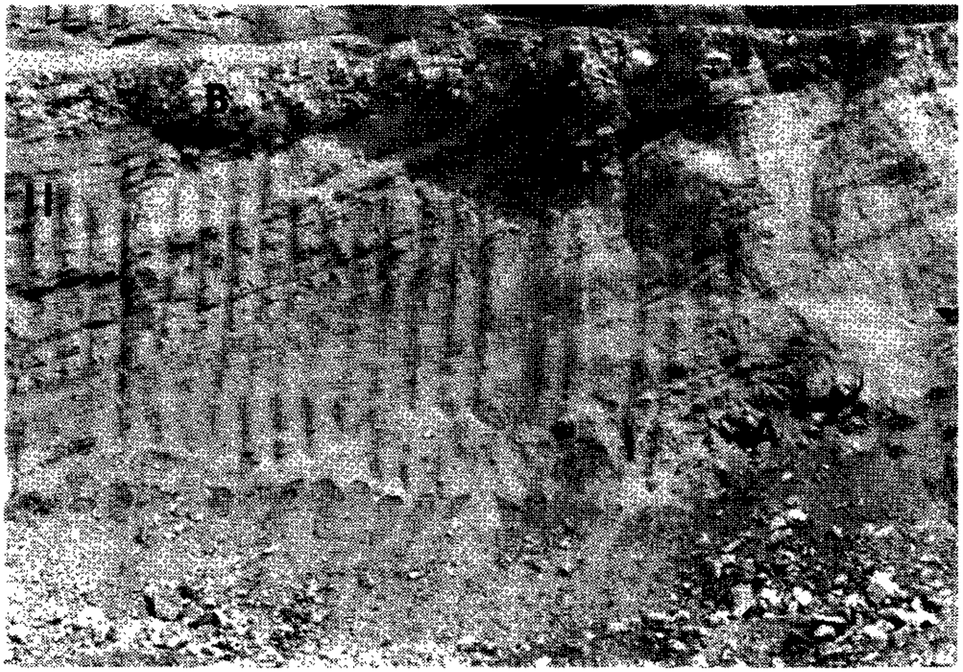

Plate 4-4-1. View of fractured bedrock (A) and lithostratigraphic units (I) and (II) at base of Valley pit excavation, Highland Valley Copper mine, British Columbia. Exposure is 12.5 metres high. Pebbly diamicton at top of photo is modern road fill (B). Unit I is interpreted as slope wash and grus.

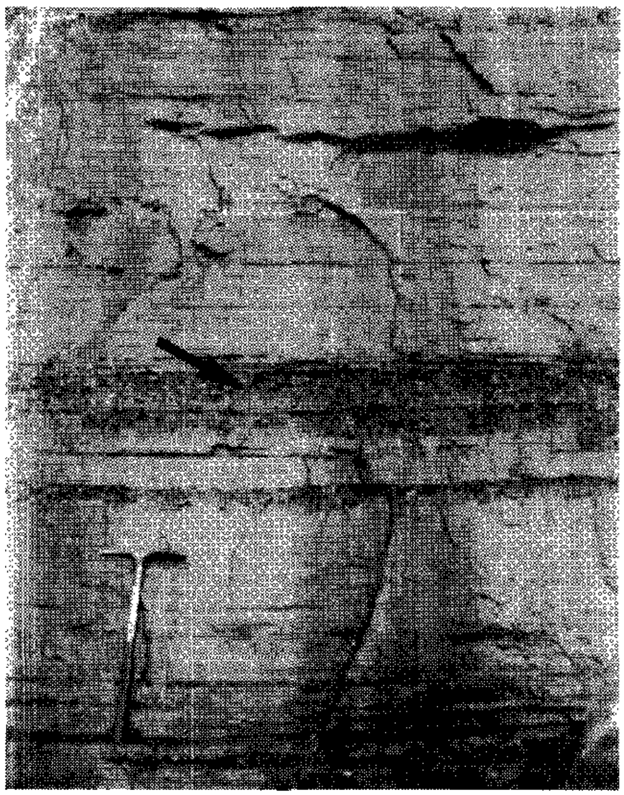

Plate 4-4-2. View of rhythmite sequence in lithostratigraphic Unit II consisting of alternating beds of silty clay and clayey silt. Pick for scale is 65 centimetres long. Arrow points to group of discontinuous matrix-supported beds. Unit is interpreted to represent glaciolacustrine sediments.

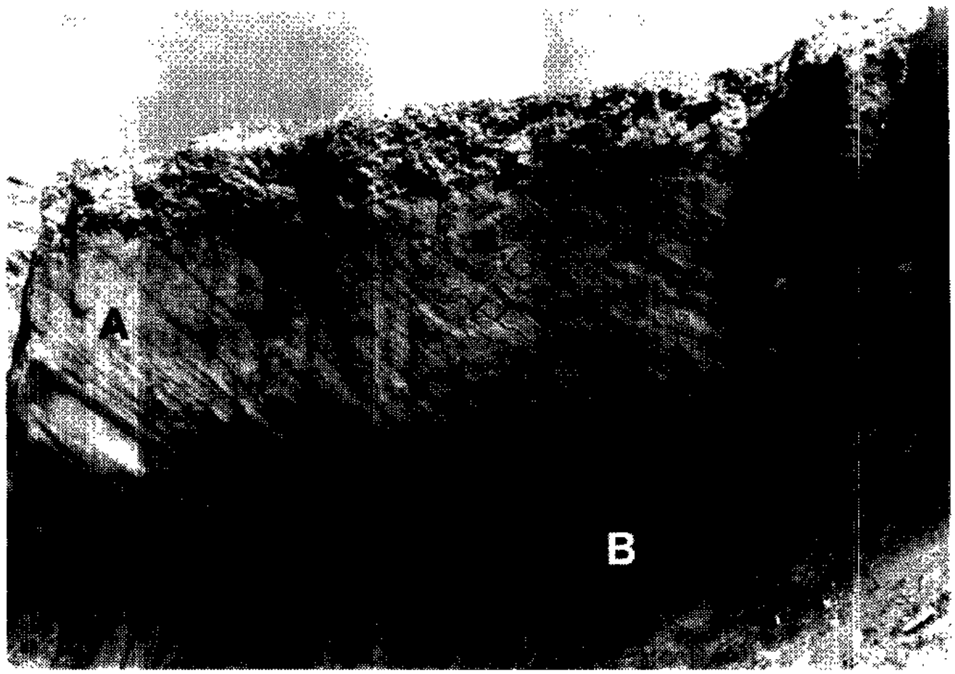

Plate 4-4-3. View of steeply inclined, alternating planar crossbeds of sand and sandy gravel of lithostratigraphic Unit III interpreted as fan-delta accumulation (A). Note transition into underlying rhythmite sequence (B).

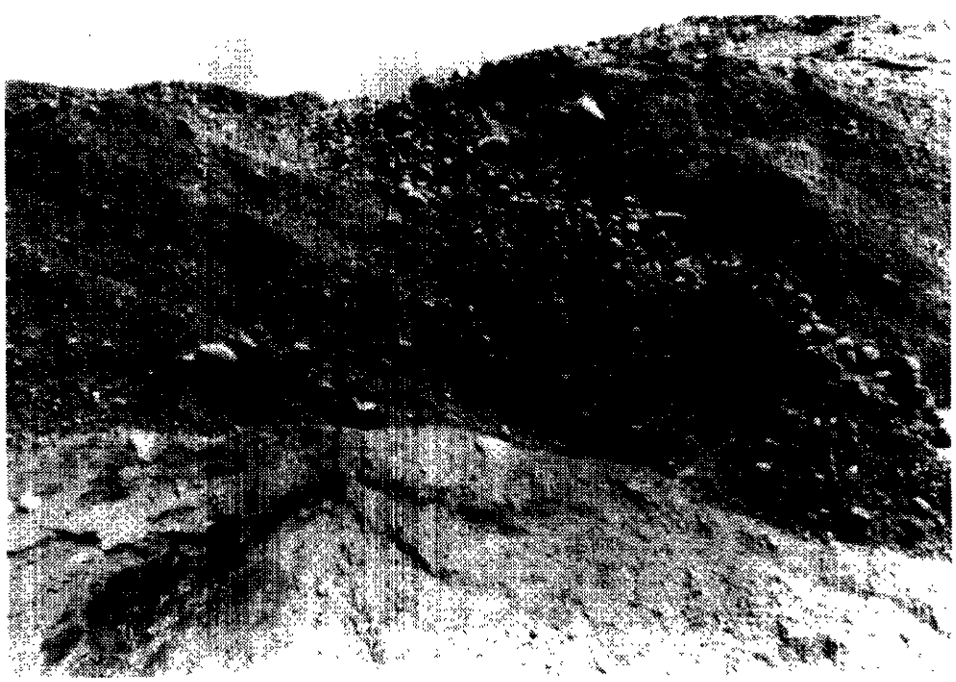

Plate 4-4-4. View of coarser beds in foreset complex of Unit III. Shovel for scale. Note fining-upwards sequences in the beds and diffuse over-sized clasts.

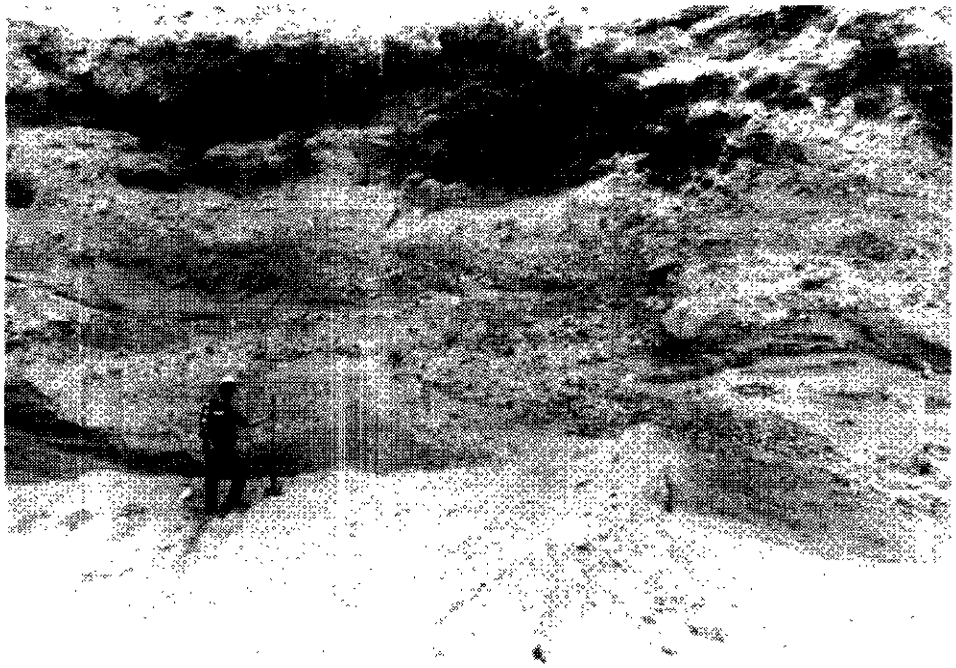

Plate 4-4-5. View of poorly sorted sand and gravel beds interbedded with poorly stratified matrix and clast-supported diamictons. Unit is interpreted as subaqueous outwash and debris flow deposits.

in the unit had a pebble fabric trending 163.9° and plunging 11.5° (S1=0.711). Clasts in all of the diamictons range in size from granules to boulders (<1 m in diameter), are angular to subrounded and are of mixed lithologies. This unit is interpreted as representing outwash deposits in a proglacial and subglacial environment (*cf.* Miall, 1977) and resedimented debris-flow accumulations in a subaqueous environment (*cf.* Eyles *et al.*, 1987).

UNIT V

This discontinuous unit consists of up to 10 metres of intercalated beds of sand and gravel. The dominant beds are moderately well sorted, stratified sandy silt and silty sand, ranging in thickness from 2 to 40 centimetres. The upper sand beds contain rare, over-sized clasts and thin (<15 cm thick) discontinuous lenses of matrix-supported diamicton. Clast-supported deposits are poorly sorted, pebbly cobble gravel beds, with openwork structure near their base. Many beds show internal grading. Inter-bed contacts are all sharp. Crossbeds dip regularly in variable directions, for example, up to 16° towards 90° and 15° towards 185°. The upper contact of this unit is indeterminate to truncated. The lower contact is sharp, erosive and curvilinear into the underlying sediments. The deposits in this unit are interpreted to represent subglacial outwash facies of an actively advancing ice mass (*cf.* Miall, 1977).

UNIT VI

Unit VI consists of up to 25 metres of diamicton beds, intercalated with isolated lenses of sand and gravel. Lenses are primarily stratified coarse sand and pebbly granules. Crossbedding in the lenses dips on average 22° towards 235°. Fine-textured horizons are discontinuous and less than 10 centimetres thick. Most of the unit is a massive to poorly stratified, matrix-supported diamicton. This poorly sorted deposit has a silty sand matrix, very low stone content (maximum clast diameter 0.7 m), and is relatively dense and compact. Clasts are subangular to subrounded. Rare pockets of sorted sand are present. A pebble fabric sample from the diamicton provided a trend of 305.7° and plunge of 05.9° (S1=0.523). Sandy interbeds support rafted diamicton rip-up clasts. Near the base of the unit, pebbles in a diamicton bed were measured and observed to have a strong (S1=0.835) fabric trending 139.6° and plunging 12.1° (Table 4-4-4). Where visible, part of this unit rests directly on bedrock, and the remaining part sharply overlies and truncates the lower sand and gravel unit. This unit is interpreted to represent a basal till accumulation (*cf.* Dreimanis, 1988).

UNIT VII

Unit VIII consists of approximately 33 metres of stratified sand, gravel and diamicton. The lower part of the unit contains beds of massive diamicton, ranging from 0.2 to 4 metres in thickness, separated by silt and fine sand beds averaging 50 centimetres in thickness (ranging from 15 to 100 cm) and 5 metres in length. Pebble fabric data from the lower diamictons provide a trend of 19.6° and plunge of 13.3° (S1=0.742). Rare over-sized clasts are present in the sandy beds. The diamicton beds are massive to stratified, poorly sorted, with a silty sand matrix, and rare clasts which are predominantly subangular to subrounded pebble to boulder size. The predominance of stratified sandy horizons (beds up to 2 m thick) increases in the middle part of the unit (Face 12) where beds are laterally extensive and continuous for distances of hundreds of metres. In the upper part of the unit, the diamicton beds show greater stratification and lack obvious sand interbeds. One of the uppermost diamictons has a pebble fabric trending 24.8° and plunging 11.3° (S1=0.853). Rare sand and gravel cut-and-fill structures, up to 2 metres thick with crossbedding dipping 14° towards 045°, are present in the uppermost exposures (Face 13). The lower contact of this unit is gradational with the underlying deposits over several metres. These sediments are interpreted to represent various depositional facies of a supraglacial environment (*cf.* Eyles, 1979).

UNIT VIII

This unit is a thin (~6 m thick), disrupted and complex assemblage of stratified sand, gravel and diamicton beds. Sandy to pebbly cobble layers are interbedded with diamicton beds (30 to 300 cm thick) near the base as a lateral facies change. These lower diamicton provided a pebble fabric sample trending 142.6° and plunging 16.1° (S1=0.657). Higher up the section, the gravel beds alternate with discontinuous lenses and beds of pebbly sand which contain rare over-sized clasts. The finer textured beds show both planar and trough crossbedding dipping 20° towards 120° and 11° towards ~90°. Clasts are predominantly rounded to subrounded throughout the unit. The basal contact is inclined, sharp and erosive to transitional with intertonguing of beds. The unit locally shows a gradual fining-upwards sequence. This unit is interpreted as representing deposits associated with *in situ* ice decay in a braided stream environment (*cf.* Ashley *et al.*, 1985).

UNIT IX

Unit XI is confined to the recently drained lakes. Deposits consist of subhorizontally stratified sand and marl and interbeds of peat and bryophytes. Freshwater shells were observed throughout the unit, but those at the base provided a date of 9600±70 years BP (TO-215). The unit represents a Holocene lacustrine accumulation which formed shortly after deglaciation and stayed in existence until the lake was drained in 1985.

GEOCHRONOLOGY

Several specimens of wood and mollusc shell were collected from Units II and III and submitted for ^{14}C dating. Previous chronologic control at the mine site has been obtained from wood samples collected by S. Daly (Highland Valley Copper Ltd.) from the base of Unit II. Resultant dates on the *Picea* specimens submitted by him are greater than 44 450 years BP (Beta-47216) and greater than 45 070 years BP (Beta-48735). The dates imply that the glaciolacustrine sediments are mid-Wisconsinan or older in age. Absolute dates are necessary to confirm the chronostratigraphy.

PALEOECOLOGY

Wood, shells and organic sediments collected by S. Daly have been analyzed previously. Wood submitted for ^{14}C dating (*see* above) has been identified as *Picea* sp. (spruce; H. Jett, personal communication to S. Daly, 28 October, 1991). Mollusc shell fragments were identified as freshwater gastropod and bivalve fragments (J. Toppin, personal communication to H. Jett, 22 October, 1991). Pollen analysis of a single organic bulk sample contained high percentages of *Artemisia* (sage), *Picea* (spruce) and *Pinus* (pine) (Table 4-4-3). The environment at the time of deposition was interpreted to have been dry and cooler than present, with grasses and sagebrush in the valley bottoms and spruce, pine and fir on the slopes. The assemblage is marginally similar to pollen spectra from Meadow Creek (about 280 kilometres due east) where Bessette sediments were dated at 41 800±600 years BP (GSC-716; Alley *et al.*, 1986).

TABLE 4-4-3
HIGHLAND VALLEY COPPER MINE POLLEN SPECTRA

TAXA	FREQUENCY
Picea sp. (Spruce)	86
Pinus (White pine)	38
Pinus contorta (Lodgepole pine)	2
Pinus sp. (species indeterm.)	53
Abies sp. (Fir)	5
Betula sp. (Birch)	3
Alnus sp. (Alder)	2
Salix sp. (Willow)	1
Graminae (Grasses)	13
Tubuliflorae	1
Artemisia (Sage)	91
Chenopodiineae (Chenopods)	3
Unidentified	1

(from H. Jetté, personal communication)

TABLE 4-4-4
PEBBLE FABRIC ORIENTATIONS FROM DIAMICTONS, HIGHLAND VALLEY COPPER MINE

NUMBER	TREND	PLUNGE	S1	S2	S3	N
A	139.6	12.1	0.835	0.142	0.023	25
B	169.3	07.3	0.546	0.435	0.019	25
C	183.1	11.2	0.560	0.396	0.044	37
D	163.9	11.5	0.711	0.265	0.024	25
E	024.8	11.3	0.853	0.123	0.024	25
F	019.6	13.3	0.742	0.238	0.020	45
G	305.7	05.9	0.523	0.345	0.032	25
H	142.6	16.1	0.657	0.323	0.020	25

Notes: S1, S2 and S3 are eigenvalues, N is sample size
See text for location of samples

DISCUSSION AND CONCLUSIONS

The purpose of this paper was to review the 1992 drift-exploration program field activities at the Valley pit of Highland Valley Copper mine and detail the stratigraphic and sedimentologic data now available. Ancillary results on paleoecology, geochronology and geochemistry await laboratory analysis. Given the results of this study and those of previous publications, an interpretation can be offered regarding the Quaternary history and environments of deposition in and near the Highland Valley.

Ice-flow patterns in south-central British Columbia suggest that an ice-divide may have existed some 150 kilometres to the north-northwest of Highland Valley during the last glaciation (Ryder *et al.*, 1991). During the final glaciation, ice-flow directions, as interpreted from large-scale ground features (drumlins, drumlinoid ridges, *etc.*), indicate a regional flow toward the south-southeast (Fulton, 1975). This orientation is confirmed by pebble fabrics from the diamictons in the Valley pit. Fabrics are variable in the light of differing genesis, however, sediments interpreted as *till* deposits agree with a depositional direction toward the southeast. We further infer that, ice thickness over the study area may have been 1000 metres or more during the last glaciation and probably much thicker during earlier glaciations, given ice-limit indications of 2000 metres elevation south of Merritt and 2500 metres west of the Thompson River and Fraser River confluence.

Pre-Late Wisconsinan glaciation(s) may have significantly eroded and overdeepened Highland Valley without leaving depositional evidence of the event (*see* Mullins *et al.*, 1990, for a discussion of glacially overdeepened valleys and lakes in the southern Interior). During the mid-Wisconsinan, Highland Valley may have supported small streams or a river at a depth considerably below the modern surface (>250 m below modern surface). At the start of the Late Wisconsinan, ice present to the northwest would have resulted in increased water flow through the valley. Ice most likely filled the Guichon Creek valley to the east first, locally damming Highland Valley and resulting in the formation of a large and deep glaciolacustrine sequence. As ice advanced from the northwest, a prograding fan-delta complex developed leaving foreset and topset bed deposits. Ice eventually overrode the area leaving behind a discontinuous till sheet. As ice retreated from the area at the end of the Late Wisconsinan, a variety of glacigenic sediments accumulated in the valley and along its slopes, including *subaqueous sediment gravity-flow deposits*, *outwash and* ablation till. Further retreat of the ice resulted in the incision of pre-existing valley-fill sediments and deposition of distal outwash deposits. These deposits were eventually covered by local lake sediments which developed in depressions previously occupied by stagnating ice blocks.

DRIFT PROSPECTING IMPLICATIONS

Three issues pertinent to drift prospecting arise from the observations reviewed in this report. First, it is axiomatic that most glacially eroded valleys parallel preglacial features which in turn owe their existence to tectonic events such as large-scale faulting.

Second, the exceptional thickness of valley-fill sediments documented in Highland Valley indicates a configuration exists which mimics the overdeepened lakes of the southern Interior Plateau. We know that large lakes such as Kamloops, Okanagan and Shuswap, as well as several others in the region, occupy structurally controlled valleys which were glacially eroded to depths exceeding 400 metres below the present surface (Mullins *et al.*, 1990). Highland Valley provides another example of this pattern, differing only in that it does not support an active lake environment but is instead filled with a complex sequence of glacial and nonglacial sediments. It is reasonable to suggest that most of the glaciated valleys in the region are similar insofar as they are probably overdeepened and now filled with complex Quaternary deposits. In the immediate vicinity of Highland Valley, this could include Pimainus Lakes valley, Guichon Creek valley and Nicola valley. The near-surface sediments in these valleys likely bear little resemblance (genetically or geochemically) to the underlying surficial deposits and bedrock. Finally, one can expect drilling costs to be high considering the potentially thick accumulation of sediment.

Third, most of the valley-fill sediments in the Highland Valley consist of glaciolacustrine deposits, a characteristic shared by the large lakes listed above and a feature probably typifying other valleys. We anticipate the results of our geochemical study will illustrate that these ancient lake sediments do indeed provide a reliable sampling medium for exploration. As such, we suggest that exploration strategies in the valleys sample lake sediments which are present at depth beneath the uppermost glacial sediment cover.

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