BC

Province of British Columbia
Ministry of Energy, Mines and
Petroleum Resources
Hon. Anne Edwards, Minister

Mineral Resources Division
Geological Survey Branch

GEOLOGY OF TERTIARY AND QUATERNARY GOLD-BEARING PLACERS IN THE CARIBOO REGION, BRITISH COLUMBIA (93A, B, G, H)

By Victor M. Levson and Timothy R. Giles

BULLETIN 89

Canadian Cataloguing in Publication Data
Levson, Victor, M. (Victoria Mathew), 1956-
Geology of tertiary and quaternary gold-bearing placers in the Cariboo Region, British Columbia (93A, B, G, H)

(Bulletin, ISSN 0226-7497 ; 89)

Issued by Geological Survey Branch.
Includes bibliographical references: p.
ISBN 0-7726-2011-3

1. Geology, Stratigraphic - Tertiary. 2. Geology, Stratigraphic - Quaternary. 3. Gold ores - Geology - British Columbia - Cariboo Region. 4. Geology, Economic - British Columbia - Cariboo Region. 5. Placer deposits - British Columbia - Cariboo Region. I. Giles, T. (Tim) II. British Columbia. Ministry of Energy, Mines and Petroleum Resources. III. British Columbia. Geological Survey Branch. IV. Title. V. Series: Bulletin (British Columbia. Ministry of Energy, Mines and Petroleum Resources) ; 89.

TN414.C32B74 1993   551.7'8'097117   C94-960029-6

DECEMBER 1993
VICTORIA
BRITISH COLUMBIA
CANADA

SUMMARY

Stratigraphic, sedimentologic and geomorphic data collected from man-made and natural exposures at 61 placer gold mining and exploration sites in the Cariboo region have been used to develop a geologic classification of productive placer settings. These are: Tertiary and pre-Late Wisconsinan paleochannel and paleofan settings; Late Wisconsinan glacial and glaciofluvial environments and; Holocene high and low-terrace, colluvial and alluvial fan settings. Differences in the geologic characteristics of the placer deposits in these settings have direct effects on mining and exploration activities. Placer deposits that underlie till of the last glaciation are invariably the most productive as they accumulated over relatively long periods of time. The precise age of many of these pre-Late Wisconsinan deposits is unknown due to the lack of dateable materials. Although many are believed to be Pleistocene interglacial depositsm, some may be Tertiary. The main difficulty in locating, evaluating and mining these deposits is a result of the overlying Quaternary sediments which obscure, and commonly deeply bury, them.

Five main auriferous lithofacies, distinguished by differences in grain size and sedimentary structures, have been recognized. In order of decreasing importance these include (with inferred depositional environments): a) massive to crude, sub-horizontally stratified gravel with weak imbrication (shallow, gravel-bed stream deposits; mainly longitudinal bar deposits); b) clast-supported, matrix-filled gravel and gravelly diamicton with coarse-clast-clusters (sediment-rich flood-flow and noncohesive debris-flow deposits); c) large-scale, trough crossbedded gravels (channel-fill deposits); d) planar cross-bedded gravels (transverse bar deposits); and e) massive, fine-grained, matrix-supported diamicton (cohesive debris-flow deposits). Regardless of the dominant lithofacies, gold concentrations are invariably high along well-developed erosional unconformities, particularly those over bedrock or clay-rich sediments.

Placer deposits known to be Tertiary in age occur mainly west of the Cariboo Mountains in the Quesnel Trough. They are typically buried by thick sequences of Quaternary sediments. Sedimentary structures, such as well-developed stratification and imbrication, and the high textural maturity of the gravels indicate deposition in well-developed fluvial systems, usually large, braided or wandering gravel-bed rivers. The distribution of these ancient channel systems is apparently largely structurally controlled, not having been influenced by glaciation. Sites along major thrust faults separating the Quesnel, Barkerville and Cariboo terranes, specifically the Spanish, Eureka and Pleasant Valley thrusts, are good exploration targets for buried Tertiary deposits. Mining of these normally cemented gravels has been productive only in a few locations in the Cariboo. Locally, however, they can contain significant gold concentrations, warranting further exploration.

Four different types of pre-Late Wisconsinan paleochannel placer settings, distinguishable mainly by paleostream gradient, present topographic position and deposit size, are recognized:

- high-gradient narrow-valley settings referred to as paleogulches,
- abandoned, high-level valleys of intermediate size and channel gradient,
- broad (hundreds of metres wide), abandoned trunk valleys with relatively low channel gradients, and
- channels buried in modern alluvial valleys with stream gradients similar to the modern channels.

The first two settings are dominated by low sinuosity single-channel, autochthonous placer deposits whereas the latter two are characterized by both autochthonous and allochthonous placers deposited in braided streams and, to a lesser extent, wandering gravel-bed river environments. Gold-bearing deposits typically consist of imbricated, moderately to well stratified and sorted, pebble to cobble gravels interpreted as fluvial channel lag and longitudinal bar deposits. More poorly sorted and stratified deposits, interpreted as high-discharge, sediment-rich, flood and debris-flow deposits, also occur but are less common.

Buried trunk-valley and high-level valley systems may have little relation to modern drainage patterns. These placers are most commonly exploited in areas where they have been partially exposed by erosion, as thick overburden is a major obstacle to mining. Paleochannel placers buried below modern alluvium have the additional problem of water drainage. These mining problems are somewhat offset by the potential richness and large volume of these placers.

Placer deposits in paleogulch settings are different from other paleochannel deposits in that they generally consist of poorly sorted, cobble to boulder-sized fluvial gravels with interbedded debris-flow deposits. The sedimentary characteristics of these deposits vary widely from bed to bed. Paleogulch placers also are generally smaller than other buried-valley placer deposits but they often contain significantly higher gold concentrations. Historically they have been the richest gold producers in the Cariboo with most operations mining deposits where modern gulch-channel erosion has removed some of the overburden. Present mining operations are focused mainly on remnant paleogulch gravel left by previous hydraulic mining operations. There is good potential for the discovery of new high-grade buried paleogulch channels, especially in high-relief areas such as along the upper reaches of Lightning, Antler and Cunningham creeks.

Paleoalluvial fan and fan-delta deposits comprise a significant part of the gold-bearing strata at two of the largest mines in the Cariboo (Spanish Mountain and the Ballarat mines). These placers are large in volume but generally are lower grade than fluvial paleochannel placers of similar age.

They consist of poorly sorted, debris-flow deposits interbedded with lenses of fluvial sands and gravels. Large foreset beds and other structures indicative of subaqueous deposition at the Ballarat mine lead to the inference that sedimentation occurred in a fan-delta environment. Like paleochannel and paleogulch placers, paleofan deposits are difficult to locate and mine because of thick overburden.

Glacial and glaciofluvial placers deposited during the last glaciation are relatively rare and lower grade than older fluvial placers. Economically viable quantities of gold contained within till occur locally where glaciers overrode preexisting, relatively rich fluvial placers. Similarly, gold-rich glaciofluvial deposits are mined where older gold-bearing gravel has been eroded by glacial meltwaters. These placers are typically poorly sorted and commonly contain clasts up to large-boulder size. Although Late Wisconsinan glacial and glaciofluvial placers generally have relatively low gold grades, they occur near the surface and therefore have minimal overburden removal costs.

Mines exploiting Holocene deposits, particularly terrace placers, are common in the Cariboo. Terrace deposits are dominated by imbricated, moderately to well stratified and sorted, pebble to small-cobble gravels with interbedded sand lenses, of fluvial channel and bar origin. Gold generally is distributed throughout the gravels, but may be concentrated in specific facies such as bar-head and channel-lag gravels. Other deposits such as overbank sand facies generally have low gold concentrations. High-level terrace gravels, deposited in proximal, aggradational, braided streams shortly after deglaciation, typically are larger in volume, more poorly sorted and lower grade than low-terrace placers. The latter are frequently mined on the downstream reaches of streams, like Lightning Creek and the Quesnel and Cottonwood rivers, where mainly fine-grained gold is recovered. Productive Holocene colluvial and alluvial fan placers are relatively rare in the Cariboo. They characteristically consist of interbedded diamicton and poorly sorted gravel deposited under paraglacial conditions. Holocene placers, of all types, are most common where gold has been reconcentrated from underlying Tertiary or interglacial placer sources.

The potential for discovery of new placer deposits is good in the Cariboo. Although there is potential in all of the geologic settings identified, preglacial and interglacial fluvial and alluvial deposits are the best targets. Based on the results of this study, large volume, preglacial, paleochannel deposits in the Quesnel Terrane in the west part of the study region are considered to have the best placer potential. The paleogeography of these channels is believed to be largely related to the distribution of regional faults such as the Spanish and Eureka thrusts. There is also good potential for the discovery of buried placers, especially paleogulch deposits, in the Quesnel Highland in the eastern part of the study area.

Due to burial by glacial and postglacial deposits, air photo and satellite data, geophysical studies (including shallow reflection and refraction seismic, ground-penetrating radar, magnetometer, electromagnetic, resistivity, and induced polarization) and drilling programs are needed to locate and evaluate pre-Late Wisconsinan paleochannel placers. In contrast, most Holocene placers are more readily evaluated and mined due to the absence of a surficial cover; generally low gold grades require that successful ventures rely on detailed sedimentologic and geomorphic information, such as large-scale surficial geology map data, during both exploration and mining phases.

An understanding of the sedimentary origin of existing placers is needed to identify new sites where gold-bearing placers have been deposited and preserved. For example, geologic studies of existing exposures add to understanding of the paleodrainage patterns of ancient fluvial systems and thereby identify exploration targets. Similarly, stratigraphic and sedimentologic data, providing information on the thickness, depth and geometry of strata, channel orientation and paleoflow direction, are required to locate and trace gold-bearing units. The information presented in this paper will contribute to this database and hopefully will assist in the identification of new placer reserves.

TABLE OF CONTENTS

PLATES

CHAPTER 1 INTRODUCTION

This report provides details on the geology of placer mining operations in the Cariboo gold mining region in central British Columbia (Figure 1). Stratigraphic and sedimentologic data were compiled in the 1989, 1990 and 1992 field seasons. Studies of gold-bearing placer deposits at 61 mining and exploration properties in the Cariboo (Figures 2 to 4) were undertaken with the objective of developing a list of geological criteria useful for recognizing placer potential. The results of these studies are used to develop regionally applicable exploration models that can be applied to undeveloped or poorly explored areas. The complexity of the geology observed indicates that detailed sedimentologic and stratigraphic studies are required in order to understand both the distribution of placer deposits in a regional sense and the location and extent of gold-bearing units at the local level.

The Cariboo Mining Division was selected for study because of its long history of placer gold production. Since 1860, the district has produced 75 000 to 100 000 kilograms (about 2.5 to 3 million ounces) of gold, more than any other placer area in British Columbia (Bulletin 21 dated 1944; B.C. Deparmtent of Mines, 1946; Boyle,1979). Several large (>200 cubic metres per day processed) placer mines are now active in the region, as well as over 200 small operations, including hand mining and exploration projects.

The justification for a new provincial government program to study the geology of placer deposits in the Cariboo was: a fourfold expansion of the legal placer mining area in the province in 1989, nearly tenfold increases in reported placer production in the 1980s as compared to previous decades, and the need for geologic data to locate new buried placers. In 1989 the provincial government expanded the area open to placer mining by approximately 240 000 square kilometres (~250 1:50 000 NTS sheets), and the need for geologic data to aid exploration programs in the new regions was recognized. Secondly, reported placer gold production, driven in part by higher gold prices, increased dramatically in the last decade, as indicated by government records (Ministry of Energy, Mines and Petroleum Resources, 1992). Gold production reported from placer mines during the 1980s was more than eight times higher than reported production during the 1970s (Figure 5). Finally, recent trends toward exploitation of deeply buried placers and lower grade deposits have required more efficient mining practices and an increased reliance on geologic data. Shallow placer gold deposits in the Cariboo, found primarily in modern river valleys, were largely depleted by historical mining operations. Approximately half of the mines investigated in this study are exploiting placers that are relatively deeply

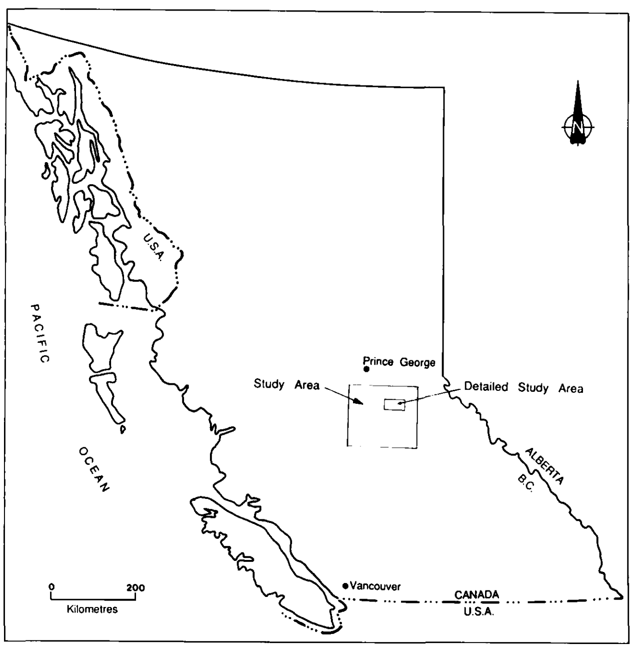


Figure 1. Location of Cariboo placer mining region. Details of the large outlined study area are shown in Figure 2.

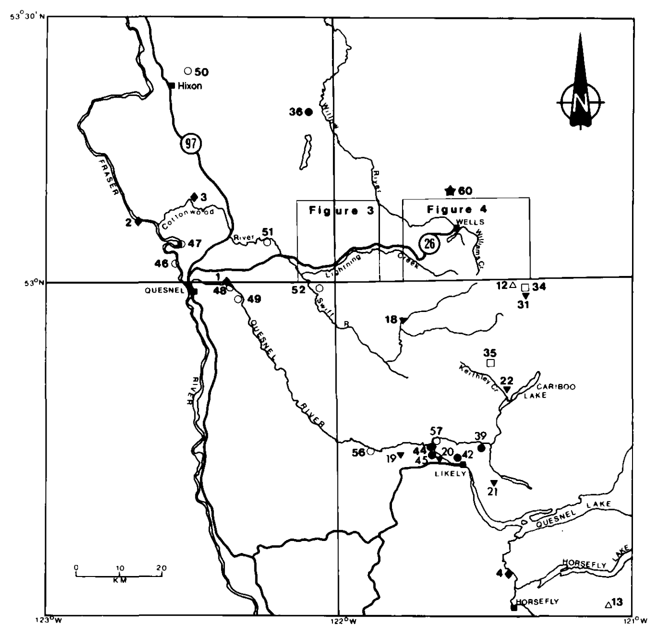


Figure 2. Major rivers, lakes and highways (heavy lines, in the Cariboo region and locations of study sites not shown on Figures 3 and 4 (insets). Symbols indicate the dominant type of placer deposit: diamonds - Tertiary placers; open triangles - buried gulch placers; solid triangles - other buried paleochannel placers; open squares - glacial placers; solid circles - glaciofluvial placers; stars - postglacial colluvial and alluvial placers; open cirlces - low-terrace placers.

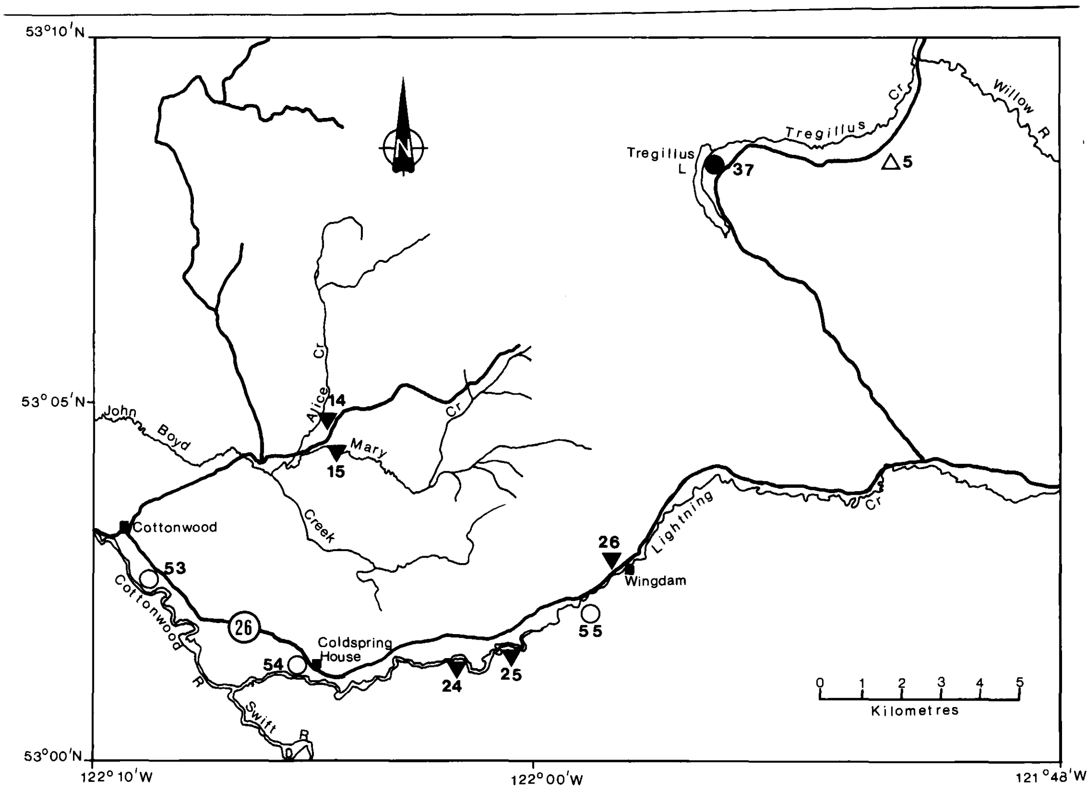


Figure 3. Major rivers, lakes and highways (heavy lines) and location of study sites in the lower Lightning Creek area (*see* Figure 2 for figure location and explanation of symbols).

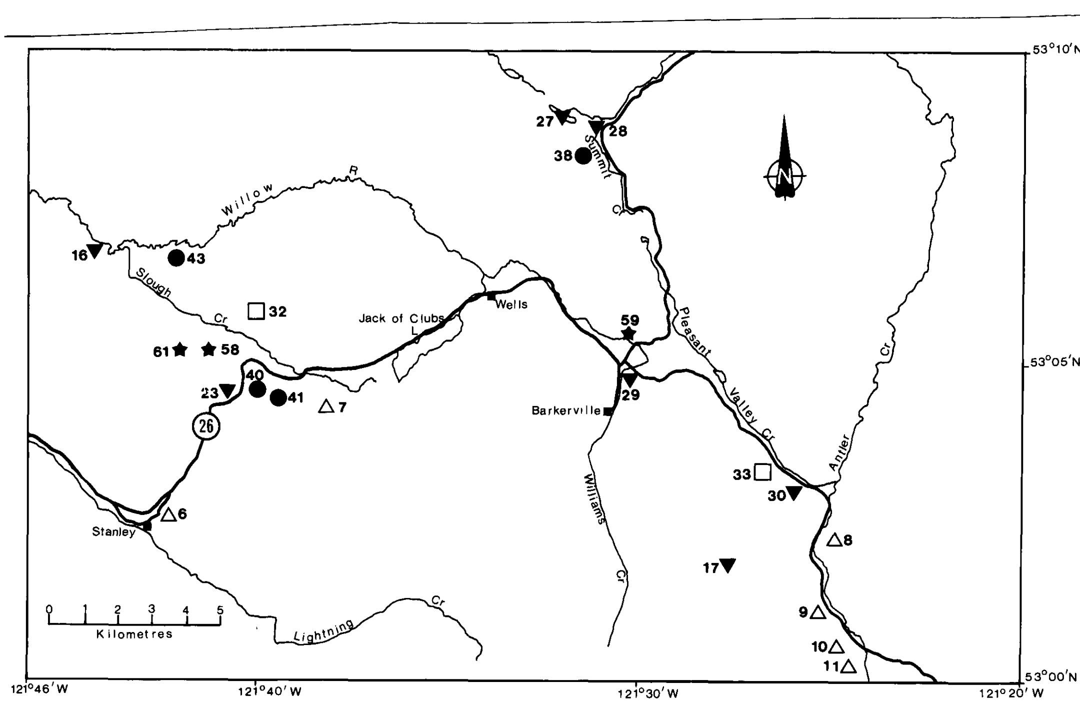


Figure 4. Major rivers, lakes and highways (heavy lines) and location of study sites in the Wells-Barkerville area (*see* Figure 2 for figure location and explanation of symbols).

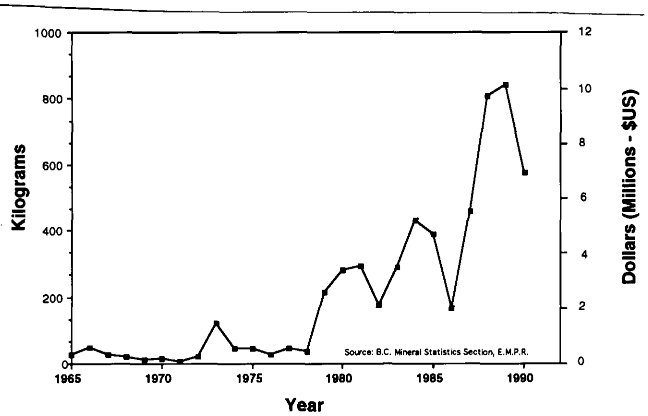


Figure 5. Recorded placer gold production in British Columbia between 1965 and 1990. Note the sharp increase in recorded production in the late 1980s.

buried by overburden, commonly glacial deposits 5 to 25 metres thick. Higher gold prices in the last 20 years have also allowed successful mining of previously uneconomic gravel. These lower grade deposits have the highest mining potential where they occur in large volumes.

METHODOLOGY

Potential study sites for this program, including both active mines and exploration properties, were identified from assessment reports and notices of work filed with the Ministry of Energy, Mines and Petroleum Resources. Sites selected for study were mainly producing mines offering good exposure and a few unmined properties where geological data had been collected by exploration companies. Sections were measured at the study sites to characterize the stratigraphic relationships of gold-bearing units to older and younger strata. The sedimentological characteristics of gold-bearing strata and overburden deposits were also recorded. Highwalls in the active mines were mapped to document lateral lithofacies variations. Descriptions of the primary and secondary sedimentary structures, structural, deformational and diagenetic characteristics, and data on the grain size (framework and matrix), pebble lithology and pebble fabric of major units were collected. Textural, petrologic, mineralogic and geochemical analyses were conducted on collected samples. Gold production in each stratigraphic unit was determined, where possible, by discussions with miners. Although at many sites it was necessary to measure only one section to describe all of the stratigraphic variability observed, at some sites the geology was sufficiently complex to warrant more detailed study and a number of sections were described.

The locations of the 61 sites where field data were collected are shown in Figures 2 to 4. The stratigraphic, sedimentologic and geomorphic characteristics of the gold-bearing deposits at each site were studied in order to develop a practical classification system and associated models of placer deposition and preservation applicable to the exploration industry. The preliminary models developed (Levson and Giles, 1991) were evaluated in 1992 with a reverse-circulation drilling and geophysical program. Detailed descriptions of the procedures for each subsurface technique and preliminary results were outlined by Levson *et al.* (1993b). The efficiency of the drilling method for recovering gold was tested by New Era Engineering Corporation using radiotracers. Geophysical methods (including borehole geophysics, seismic reflection and refraction techniques and ground-penetrating radar) were evaluated in conjunction with the Geological Survey of Canada and industry. The effectiveness of these geophysical techniques for evaluating buried deposits will be discussed elsewhere.

REPORT ORGANIZATION AND USE

This report is organized to assist prospectors and miners in developing placer properties by first providing a regional geologic framework, and secondly by giving site-specific data on which property-scale decisions can be based. It is recommended that the bedrock geology of a new property under investigation first be identified using the compilation maps provided in Chapter 2. Reference should also be made to the original geology maps, applicable to the area in question, from which the compilation maps were derived (*see* references on map legends). An analysis of the drainage basin or probable paleodrainage area, if known, should then be made in relation to the bedrock geology. Bedrock units or structural zones with potential as source rocks can be compared with the locations of placer producing streams in the region of interest. Settings where modern or paleodrainage areas significantly intersect favourable bedrock conditions can thus be identified. Properties that have bedrock characteristics similar to those in adjacent, historically productive watercourses can also be recognized.

The final step in this data evaluation is to identify sites described in Chapter 5 (and Appendix B) of this report that are located near or in geologic settings similar to the property of interest. For this purpose, all placer deposits discussed have been classified and are organized throughout this report (as well as on Figures 2 to 4 and 6 to 12) by geologic setting. Each setting is distinguished by geomorphic, stratigraphic and sedimentologic characteristics that can be readily observed in the field, as discussed in Chapters 3 and 4. The main geologic settings described include: placer deposits of presumed or known Tertiary age, pre-Late Wisconsinan buried gulch, alluvial fan and channel placers, Late Wisconsinan glacial and glaciofluvial placers and Holocene terrace, colluvial and alluvial fan placers. General interpretations of sedimentary lithofacies and depositional environments within each of the main placer settings, and summary descriptions, including cross-sections, composite stratigraphic columns and correlation diagrams, are presented in Chapters 3 and 4. Detailed discussions of the economic geology and placer potential of individual properties and surrounding areas are presented in Chapter 5. Data on gold content and character, where available, are also provided in the property descriptions in Chapter 5.

Comparisons of the geology at new sites with that described in other areas may be useful in exploration, development and mining activities. For example, an understanding of the stratigraphy described in analogous settings will aid in property development decisions relating to stratigraphic controls on gold occurrence. Complete descriptions of sections measured at properties in each of the geologic settings described in Chapters 3 to 5 are provided in Appendix B of this report. The stratigraphic sections include detailed information relevant to placer mining and exploration, such as thickness, paleoflow directions, consolidation, cementation, maximum clast size and clay content, of both gold-bearing and overburden strata, as well as other supplementary data.

PREVIOUS WORK

Geologic descriptions of Cariboo placer deposits first appeared in the literature in 1874 in British Columbia Minister of Mines Annual Reports. Maps of the main gold-bearing creeks of the Cariboo district were compiled by Bowman (1895) but no accompanying report describing the placers was produced. The first comprehensive descriptions of placer and lode gold deposits were provided by Uglow and Johnston (1923) and Johnston and Uglow (1926, 1933) for the Wells-Barkerville area, Cockfield and Walker (1933) for the Quesnel area and Holland (1948) for the Stanley area. A tremendous wealth of historical information and descriptions of local geology are provided in Johnston and Uglow (1926) and, as this information is not repeated here, interested readers should refer to that memoir. Although an excellent compilation of historical placer production in British Columbia is available (Holland, 1950; reprinted in 1980), little detailed information on gold production has been collected or published in the last 50 years. The surficial geology of the study area was mapped by Tipper (1971) and recent investigations on the Quaternary and placer geology have been made by Clague (1987a, b; 1988; 1989a, b; 1991) and Clague *et al.* (1990).

Although detailed sedimentological evaluations of placer deposits have been conducted in unglaciated areas (*e.g.*, Smith and Minter, 1980; Morison and Hein, 1987), the geology of placer deposits in glaciated terrains remains poorly understood. However, due to diminishing resources in unglaciated regions, more emphasis has recently been placed on the study of placer deposits in glaciated areas (Levson and Morison, in press).

Depositional environments of Cariboo placer deposits were recently discussed by Eyles and Kocsis (1988; 1989a, b), Levson (1990, 1991a) and Levson *et al.*, (1990). A suite of geologic settings representative of each of the main placer producing environments in the Cariboo was presented by Levson and Giles (1991) and is the basis of the classification used here. Geological factors relevant to exploration, evaluation and mining of placer deposits in each of the main settings, and some implications for lode gold exploration, were presented by Levson (1991b). Subsurface methods of evaluating placer deposits in the Cariboo, including reverse-circulation drilling, ground-penetrating radar, seismic reflection and refraction surveys, and borehole geophysics were recently discussed by Levson *et al.* (1993a, b). Detailed geological data are still lacking for many other areas of British Columbia including the well known placer areas in the Dease-Cassiar, Omineca, Lillooet, Similkameen and Fort Steele mining districts.

A number of detailed descriptions of placer deposits in glaciated areas, providing information of particular relevance to the Cariboo district, have been presented in recent years for several regions including the Atlin (Levson, 1992a; Levson and Kerr, 1992; Levson and Blyth, 1993, in press) and Tulameen (Raicevic and Cabri, 1976) areas in British Columbia, the Clear Creek (Morison, 1983a,b, 1985), Dublin Gulch (Boyle and Gleeson, 1972) and Livingstone Creek (Levson, 1992) areas in the Yukon, the Valdez Creek (Reger and Bundtzen, 1990), Skagway (Bundtzen, 1986) and Nome (Nelson and Hopkins, 1972; Barker *et al.*, 1989) areas in Alaska, and the Chaudière River area in southeastern Quebec (Shilts and Smith, 1986, 1988). Regional discussions of placer gold occurrences in other glaciated regions have also been provided for Ontario (Ferguson and Freeman,1978), Nova Scotia (Samson, 1984), Siberia (Kazakevitch, 1972; Boyle, 1979), the contiguous United States (Yeend and Shawe, 1989), Alaska (Cobb, 1973), New Zealand (Williams, 1974; Pizey, 1991) and South America (Herail *et al.*, 1989a, b; Herail, 1991; Hirvas, 1991). Placer deposits in many glaciated areas can be highly productive as illustrated by the Valdez Creek mine, the largest gold producing mine in Alaska for the last several years (Reger and Bundtzen, 1990). Deposit models applicable to paleochannel placers in glaciated parts of the Canadian Cordillera were recently presented by Levson *et al.* (1993c).

ACKNOWLEDGMENTS

The authors would like to thank all the miners whose properties are described in this report for providing information and access to their properties, and other members of the Cariboo placer mining community who provided information and assistance, including those listed below. We also acknowledge the support of the of Cariboo Mining Association. The manuscript was reviewed by John Clague and John Newell and their comments greatly improved the final version. Many of the figures were drafted by Chris Smith and Scott Henthorn. Special thanks are extended to Stan Bergunder and Norm Olausen (Golden Bench mine), Bert Ball (Wilderness Resources Ltd.), Randy Clarkson (New Era Engineering Corp.) Debbie Corless and Lee Frank (Corless Tertiary mine), Bruce Costerd (Gallery Resources Ltd.), Marten Douma and Jean Pilon (Geological Survey of Canada), Don Kirkham and Stuart Spiers (Dragon Mountain Placers Ltd.), Ed Kruchkowski and Jack Wyder (Alice Creek mine), Dale Pauls (Beaver Pass Exploration and Development Ltd.), Dan Romanow (Fontaine Creek mine) and Gunnar Slack and Chris Armstrong (Tercon Contractors Ltd.). Technical information was also provided by Fred Andrusko (Yanks Peak Resources Ltd.) and Brian McClay (Mosquito Consolidated Gold Mines Ltd.). James and Greg Devins of Dateline Contracting Ltd. are thanked for providing efficient, high quality, drilling services. Excellent field assistance was provided by Colleen Bauer in 1992. Laboratory analyses were performed by D. Arnold (radiocarbon dating), J. Borges (pebble lithology analysis), J. Harakal (K-Ar dating), R. Huneault (heavy mineral determinations), R.

Mathewes (palynological studies), J. Westgate (tephra identification), and K. Woolf (grain size analyses). Thanks are also extended to the following individuals who contributed in various other significant ways to this report: F. Ambler, A. Bolduc, J. Bot, S. Brewer, D. Carter, G. Carter, A. Corden, E. Darvill, D. and R. Drinnan, B. Dyson, S. Farrow, E.L Faulkner, T. Garrow, B. Grant, T. Hatton, J.B. Knight, S.P. Kocsis, L. Kovacs, H. Lavender, N. Lyell, E. LeNeve, R. MacPherson, B. Madu, B. Marrs, P.F. Matysek, B. and M. McCullagh, S. McGuire, P. and V. McKeown, K.C. McTaggart, H. Myers, W. Nemanishen, F. Nestel, N. Olausen, D. and W. Patenaude, J. Peters, M. Poschner, L. Shunter, E. Sommerfelt, W. Streicek, L. Tattersall, S. Taylor, T. and G. Toop, D. and R. Trites, A. and S. Uruski, B., G. and M. van Halderen, D. Williams, W. Wilkinson, N. Wood and W. Zolinski.

CHAPTER 2 GENERAL GEOLOGY

REGIONAL GEOLOGY

Regional bedrock mapping in the study area was conducted by Holland (1954), Sutherland Brown (1957, 1963), Tipper (1959, 1961), Campbell *et al.* (1973), Campbell (1978) and more recently by Struik (1988), Bloodgood (1988), Bailey (1989) and Panteleyev and Hancock (1989a). Regional compilation maps were produced by Tipper *et al.*, (1979) and Bailey (1990).

The Cariboo Mining Division straddles the Intermontane and Omineca morphogeological belts and is underlain, from west to east, by rocks of the Quesnel, Barkerville, Slide Mountain and Cariboo terranes (Figure 6). The terranes are tectonically distinct and characterized by unique stratigraphic successions. The Quesnel Terrane consists of Upper Triassic and Jurassic island-arc volcanic, volcaniclastic and fine-grained clastic rocks. The Barkerville Terrane is composed of Precambrian and Paleozoic continental shelf and slope clastic rocks with minor carbonate and volcaniclastic rocks. In the study area it is dominated by quartzites and phyllites of the Snowshoe Group. The Slide Mountain Terrane consists of Mississippian to Permian, rift-floor pillowed basalts and cherts with minor diorite, gabbro and ultramafic rocks. The Cariboo Terrane consists of continental shelf clastic and carbonate rocks, mainly of Precambrian to Devonian age in the study area (Struik, 1986,1988).

The Cariboo and Barkerville terranes are separated by the northeast-dipping Pleasant Valley thrust. The two terranes were juxtaposed between Pennsylvanian and Early Jurassic time. The Slide Mountain Terrane was thrust over the Barkerville and Cariboo terranes along the Pundata thrust during the Triassic or Early Jurassic. The Quesnel and Barkerville terranes are separated by the southwest-dipping Eureka thrust but they may also be in stratigraphic contact (Struik, 1988). The Quesnel Terrane is bounded to the west by a high-angle fault that is probably a continuation of the Pinchi fault to the northwest (Bailey, 1990). Between this fault and the Eureka fault is the Quesnel Trough, a structural and depositional back-arc basin with an overlapping island-arc volcanic assemblage. Fore-arc oceanic strata of the Cache Creek Group occur west of the Quesnel Terrane.

QUATERNARY GEOLOGY

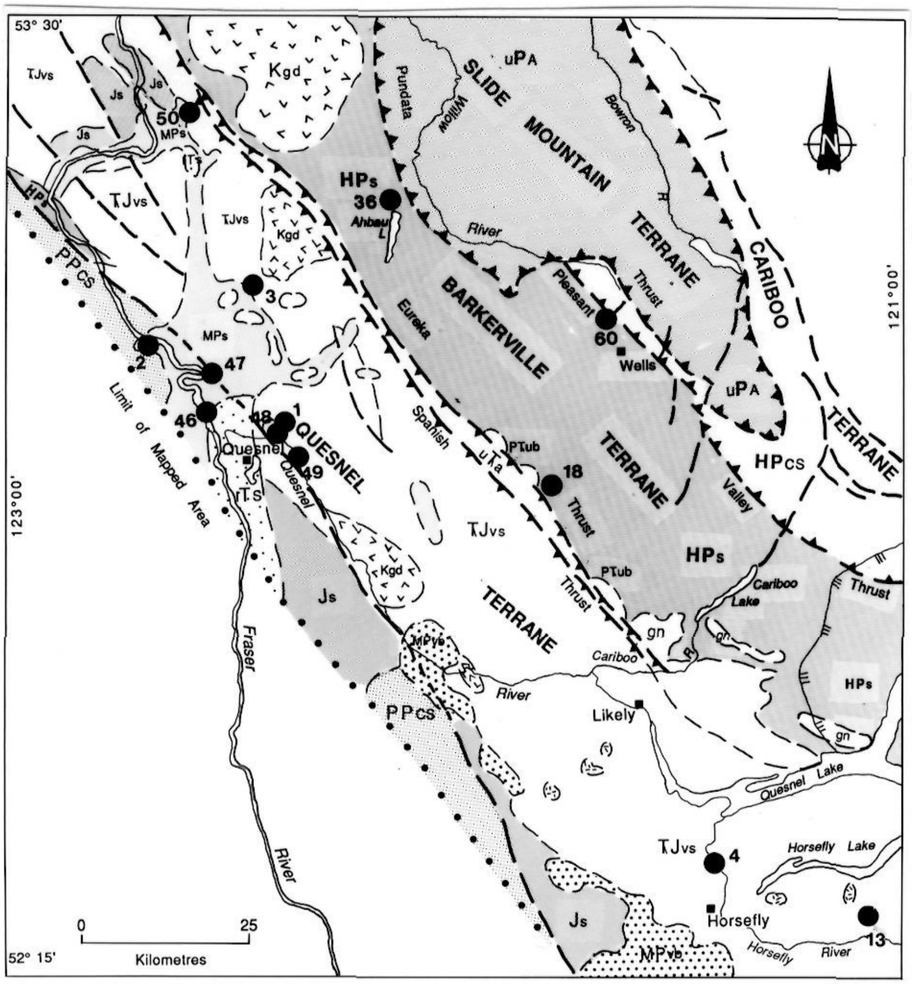
The Cariboo region was glaciated repeatedly during the Pleistocene. Sediments predating the last glaciation (Late Wisconsinan Fraser Glaciation) occur at many sites in the area and include fluvial gold-bearing gravel as well as till and ice-stagnation deposits of the penultimate glaciation (Clague, 1991). Study of pollen collected from interstadial sediments at two localities in the Cariboo indicates that the region was ice-free from 40 000 to more than 51 000 years ago (Clague *et al.*, 1990). The area supported a forest parkland to grassland vegetation in the early part of this period and a spruce forest with dry openings and local fens from 46 000 to 40 000 years ago, indicating a climate cooler and drier than today.

During the advance phase of the Late Wisconsinan glaciation, thick sequences of glaciofluvial gravel were deposited in braided outwash streams. Ice damming of tributary drainages by trunk-valley glaciers, such as at Rucheon Creek (Site 5), was common and resulted in deposition of glaciolacustrine silt and clay and thick deposits of deltaic sand and gravel. During the maximum of the last glaciation, ice flowed westerly from the Cariboo Mountains and coalesced with Coast Mountain ice resulting in a northerly regional flow in the west part of the study area (Tipper, 1971). During ice retreat ice-dammed lakes were again common, notably in the Cariboo and Quesnel River valleys (Clague, 1991). Aggradation of braided stream gravel in most major valleys was followed by river incision and the development of successively lower terraces (*e.g.*, Site 1).

BEDROCK CONTROLS ON GOLD PLACERS

Rocks of the Barkerville Terrane host most of the main lode gold occurrences in the area and are believed to be the main source of placer gold (Struik, 1988). Rocks of the Snowshoe Group are the most significant, especially the Downey and Harveys Ridge successions, and to a lesser extent the Eaglenest and Ramos successions. Similarities in lithology and age suggest that some of these rock sequences may be lateral equivalents. The successions consist mainly of micaceous quartzites and interbedded phyllites. Other less common rock types include schist, slate, siltstone, limestone, marble, amphibolite and meta-tuff. Productive placers overlie the Downey succession in the Wells-Barkerville area and the Harveys Ridge succession farther to the west (Figure 7).

The spatial and genetic relationship between rocks of the Snowshoe Group and placer deposits in the area has recently been corroborated by trace element geochemistry studies of lode and placer gold by Knight and McTaggart (1990). These authors have also presented convincing evidence to discredit the widely held hypothesis that lode gold in the Cariboo was dissolved and reprecipitated to form nuggets. Although oxidation of host minerals (*e.g.*, pyrite) may release trace gold to solutions that can, under rare circumstances, reprecipitate gold to form nuggets, this process typically results in the formation of nearly pure gold (Boyle, 1979; Mann, 1984; Vasconcelos and Kyle, 1989; Knight and McTaggart, 1986, 1990). There also appears to be no relationship between changes in chemical composition of gold grains with distance travelled from primary lode sources (Herail *et al.*, 1990). Very few of the several hundred analyses of gold fineness presented by Knight and McTaggart



LEGEND

TERTIARY

MPvb	Olivine basalt flows, breccia, tuff
MPs	Sandstone, shale, conglomerate, diatomite, lignite
lTs	Paleogene conglomerate, sandstone, mudstone, lignite

CRETACEOUS

Kgd	Granodiorite, quartz monzonite, quartz diorite

TRIASSIC - JURASSIC

Js	Shale, greywacke, conglomerate
TJvs	Andesite, basalt, tuff, breccia, conglomerate, greywacke, shale, limestone
uTa	Phyllite, argillite, siltstone, limestone, quartzite, schist
(pattern)	Syenite, monzonite and diorite; minor ultramafics, gabbro

PERMIAN AND/OR TRIASSIC

PTub	Peridotite, dunite, pyroxenite, serpentinite

PENNSYLVANIAN AND PERMIAN

PPCs	CACHE CREEK GROUP Ribbon chert, argillite, limestone, greenstone

MISSISSIPPIAN TO PERMIAN

uPA	SLIDE MOUNTAIN GROUP Basalt, breccia, tuff, chert, argillite, sandstone, limestone, conglomerate

HADRYNIAN TO PALEOZOIC

HPcs	CARIBOO, BLACK STUART AND KAZA GROUPS Limestone, dolomite, argillite, phyllite, quartzite, schist, chert, breccia, sandstone, conglomerate
HPs	SNOWSHOE GROUP Mainly micaceous quartzite and phyllite; sandstone, conglomerate, schist, amphibolite, marble, gneiss

UNKNOWN AGE

gn	Augen granite, granodiorite, gneiss
- - -	Geological Contact
▬ ▬ ▬	Fault (Known or Inferred)
▲▲▲	Thrust Fault
●	Placer Sites Visited
∼	Placer Producing Streams

Modified from:

Tipper, H.W., R.B. Campbell, G.C. Taylor and D.F. Stott. 1979. Parsnip River, British Columbia, Sheet 93; Geological Survey of Canada, Map 1424A, 1:1 000 000.

Struik, L.C. 1988. Structural Geology of the Cariboo Gold Mining District, East-central British Columbia; Geological Survey of Canada Memoir 421.

Figure 6. Regional geology of the Cariboo placer mining area showing major faults and tectonic terranes. Numbered locations are study sites not shown on the more detailed bedrock maps of Figures 7 to 12.

(1990) revealed nearly pure gold, and for this reason as well as several others, such as the geochemical association of known lodes and nearby placers, the typically abraded shape of the grains and the presence of angular quartz or pyrite rather than fluvially rounded inclusions, they concluded that the gold was of detrital origin. More conclusively, the analysed cores of compound nuggets have been found to be compositionally identical (Knight and McTaggart, 1990) indicating that they were originally one nugget from which silver was preferentially leached, rather than several individual grains joined by reprecipitated gold as is commonly thought (*e.g.*, Eyles, 1990 and references therein).

Lode gold in the Downey succession is found in small, branching, pyritic quartz-vein systems in micaceous quartzite and argillaceous rocks of the Rainbow Member and in massive pyrite replacement deposits within or at the contacts of limestone horizons in the Baker Member (Sutherland Brown, 1957; Alldrick, 1983). The two types of deposits are the same age and occur in hinge zones and less commonly along limbs of folds. Lode gold is confined to rocks of chlorite grade metamorphism northwest of the garnet isograd (Struik, 1988). The isograd crosses the Barkerville Terrane north of Quesnel Lake (Figure 6) and all of the placer properties visited in this study occur in greenschist facies rocks to the northwest.

Within the Cariboo Terrane, productive placers overlie siltstone and quartzite of the Midas Formation along the Cunningham River. A number of productive deposits also occur along or near major thrust faults bounding the Cariboo, Barkerville and Slide Mountain terranes (Figures 6 to 12). Some of the placers in the Cariboo Terrane, and possibly also the Barkerville Terrane, may be derived from gold-bearing veins developed in brittle rocks above and below thrust faults such as the Pundata and Pleasant Valley thrusts. Ash and Arksey (1990) found that carbonatized ultramafic rocks (listwanites) can be used to identify areas of potential gold mineralization in some rock sequences such as serpentinite units in the Slide Mountain Terrane.

The distribution of placer deposits in the Quesnel Terrane is largely controlled by the geography of regional river systems of Tertiary age (Lay, 1940, 1941) and locally by the occurrence of auriferous quartz veins in Triassic phyllites. Auriferous gravels deposited in Miocene rivers in the Horsefly-Likely region are generally not derived from local bedrock, but contain abundant garnet and kyanite indicating a source in high-grade metamorphic rocks to the east (Panteleyev and Hancock, 1989b). Heavy mineral concentrates from drill samples recovered from buried placers farther north (Levson *et al.*, 1993a) in the Reddish Creek, Lightning Creek, Cottonwood River and Sovereign Creek areas (near Sites 18, 24, 51 and 52, respectively, Figures 2 and 3) also contain high proportions of garnet (up to 35%) and staurolite (up to 27%). Streams depositing the paleoplacers in these areas must also have had source areas in the high-grade metamorphic rocks to the southeast as rocks in present drainages to the east are only biotite and chlorite grade (Read *et al.*, 1991). Major northwest-trending faults such as the Eureka thrust, presumably provided a major structural control on preglacial drainage patterns in the area and they

LEGEND FOR FIGURES 7 - 10

LEGEND

QUESNEL TERRANE	
UPPER TRIASSIC	
uTa	Phyllite, argillite, siltstone, limestone, quartzite, schist, greenstone, tuff
SLIDE MOUNTAIN TERRANE	
MISSISSIPPIAN TO PERMIAN	
	SLIDE MOUNTAIN GROUP
uPA	ANTLER FORMATION: pillow basalt, breccia, diorite, chert, greywacke, serpentinite
BARKERVILLE TERRANE	
PALEOZOIC?	
	SNOWSHOE GROUP
uPIM	ISLAND MOUNTAIN AMPHIBOLITE: amphibolite, minor siliceous mylonite
uPHM	Hardscrabble Mountain succession: siltite and phyllite, micaceous quartzite, limestone, minor metatuff?
PB	Bralco succession: marble
Pi	Foliated diorite, augite porphyry basalt, gabbroic rocks; undifferentiated diabase, diorite
PALEOZOIC	
PQL	QUESNEL LAKE GNEISS: Potassium feldspar porphyritic granitic orthogneiss
	SNOWSHOE GROUP
PE	Eaglenest succession: micaceous quartzite and phyllite
PD	Downey succession: micaceous quartzite and phyllite and undifferentiated rocks
PA	Agnes succession: quartzite-clast conglomerate, quartzite, minor limy conglomerate
PGP	Goose Peak succession: quartzite, minor conglomerate
PHR	Harveys Ridge succession: micaceous quartzite and interbedded phyllite, schist, siltite, and minor micritic limestone and undifferentiated rocks
HADRYNIAN OR PALEOZOIC	
HPT	Harveys Ridge succession: micaceous quartzite, phyllite and schist
HADRYNIAN ?	
HKE	Keithley succession: micaceous quartzite and phyllite, minor marble
HKK	Kee Khan marble: marble, calcareous sandstone, micaceous quartzite, phyllite
HT	Tregillus succession: micaceous quartzite, phyllite, schist, conglomerate
HR	Ramos succession: micaceous quartzite and phyllite, sandstone and undifferentiated rocks
HPS	Snowshoe Group undifferentiated: mainly micaceous quartzite and phyllite
CARIBOO TERRANE	
DEVONIAN TO MISSISSIPPIAN	
DMG	GUYET FORMATION: conglomerate, breccia, granule quartzite and slate
Dw	WAVERLY FORMATION: basaltic tuff, volcaniclastics, pillow basalt, siltite
OMBS	Black pelite unit: slate, argillite and cherty argillite, limestone, dolostone and silicified limestone
LOWER CAMBRIAN	
lCM	MURAL FORMATION: grey limestone, minor shale and argillite
HADRYNIAN AND/OR CAMBRIAN	
HCM	MIDAS FORMATION: siltstone and quartzite, minor shale and argillite
HCu	undivided: quartzite, siltstone, argillite, shale, limestone, phyllite, schist
HADRYNIAN	
HC	CUNNINGHAM FORMATION: limestone, minor shale, argillite and dolostone
- - -	Geological Contact
— — —	Fault (Known or Inferred)
▲ ▲ ▲	Thrust Fault
•	Placer Sites Visited
~	Placer Producing Streams
Source:	Struik, L.C. 1988. Geology of the Wells, Spectacle Lakes, Swift River and Cariboo Lake map areas, Cariboo Land District, British Columbia; *Geological Survey of Canada,* Maps 1635A, 1636A, 1637A and 1638A; 1:50,000.

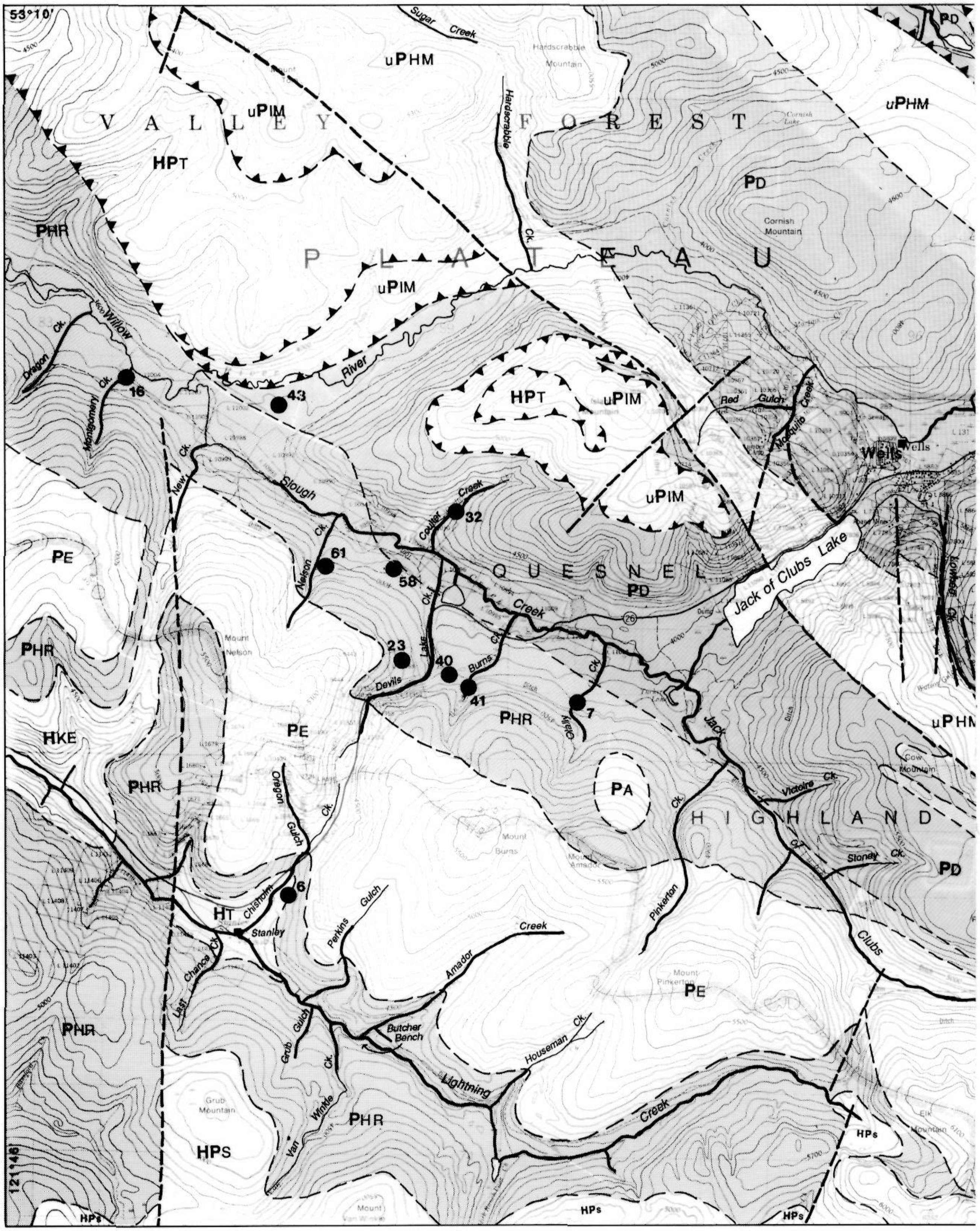
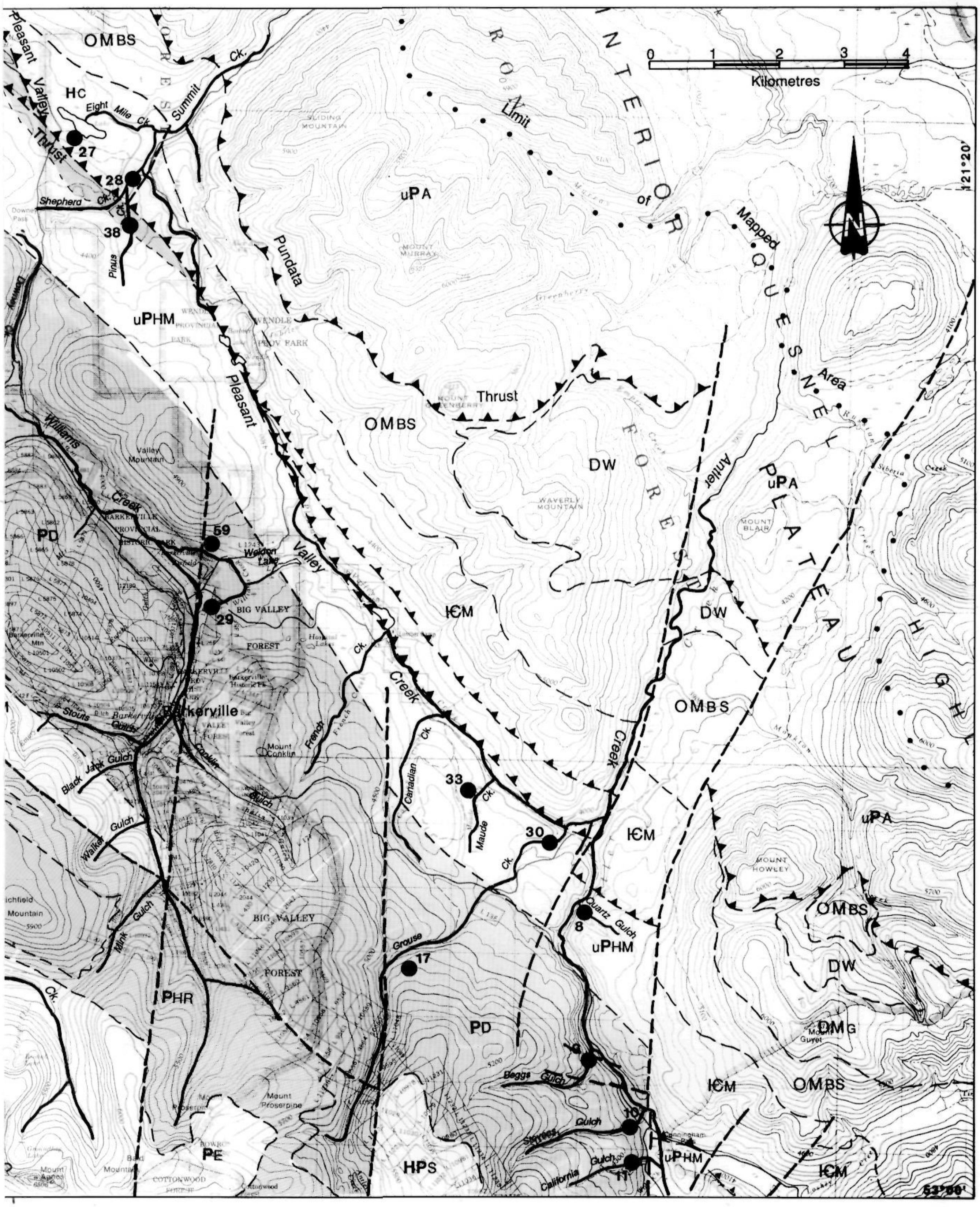


Figure 7. Bedrock geology, placer producing streams (heavy lines) and detailed study sites (solid circles) in the Wells-Barkerville area. Formations with known lode source potential are shaded. (Figure continued on next page.)


0 1 2 3 4
Kilometres
121°20'
53°00'
OMBS
HC
uPA
uPHM
PD
ꞮCM
DW
DMG
PHR
PE
HPS
Pleasant Valley Thrust
Pundata Thrust
Limit of Mapped Area
INTERIOR FOREST
QUESNEL PLATEAU
Eight Mile Ck.
Summit Ck.
Shepherd Ck.
Pinus Ck.
Williams Creek
Pleasant Valley Creek
Antler Creek
Canadian Ck.
Maude Ck.
Grouse Ck.
Quartz Gulch
Beggs Gulch
Stevens Gulch
California Gulch
Black Jack Gulch
Walker Gulch
Mink Gulch
Stouts Gulch
Conklin Gulch
French Ck.
Barkerville
Wendle Lake
Valley Mountain
Waverly Mountain
Mount Blair
Mount Howley
Mount Guyet
Mount Conklin
Mount Proserpine
Richfield Mountain
BIG VALLEY
FOREST
27
28
38
59
29
33
30
8
17
9
10
11

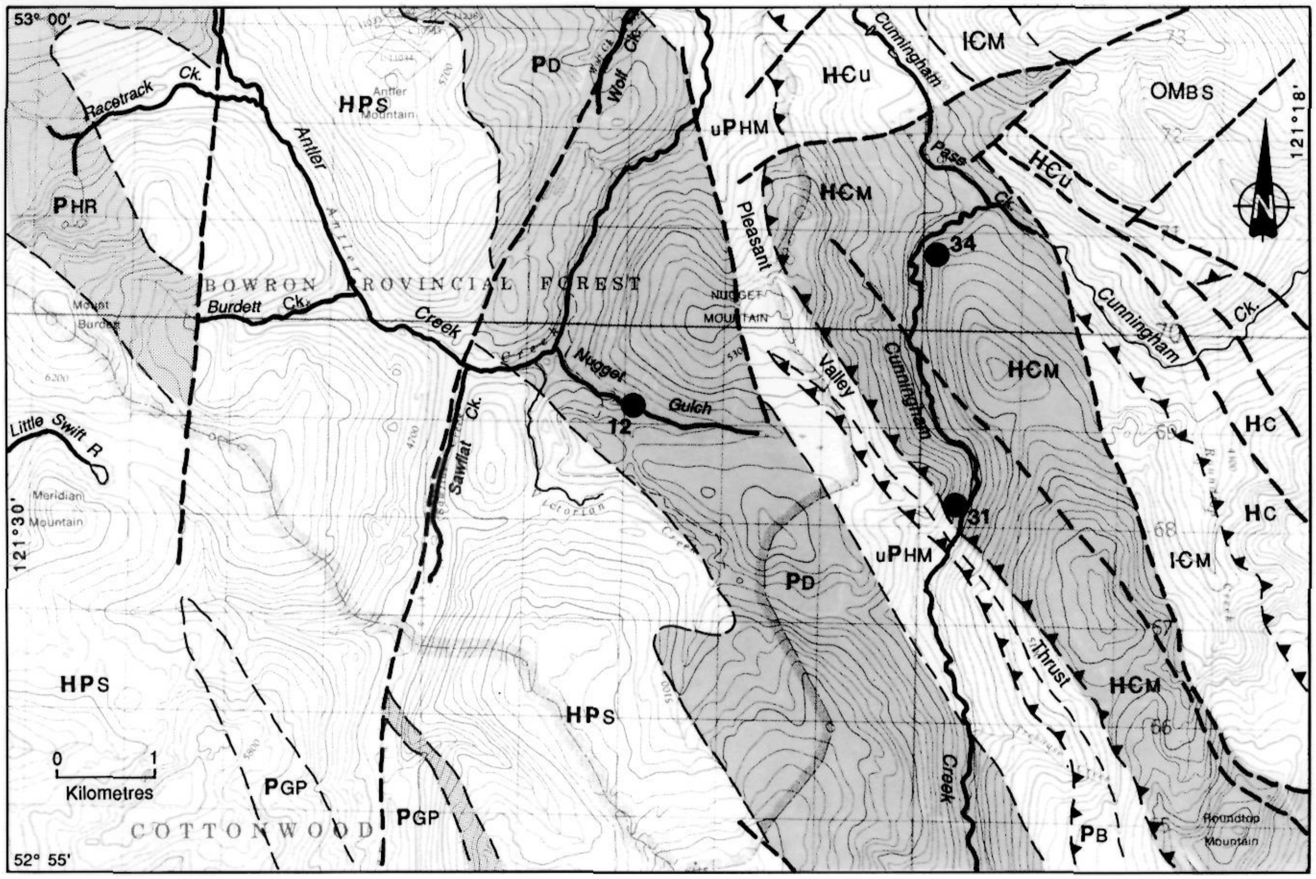


Figure 8. Bedrock geology, placer producing streams (heavy lines) and detailed study sites (solid circles) in the upper Antler - Cunningham Creek area. Formations with known lode source potential are shaded (*see* common legend page 9).

are believed to be good exploration targets (Levson *et al.*, 1993a).

On a more local scale, bedrock geology affects the accumulation of placer gold by creating river channel irregularities and bedrock traps such as potholes, resistant strata (natural riffles and ledges), openings in fissile bedrock (crevices, bedding and cleavage planes) and fault zones (Maurice, 1986; Teeuw *et al.*, 1991). In addition, stream profiles and bed conditions such as channel roughness are largely controlled by the local bedrock geology. One of the most efficient bedrock traps for collecting gold, occurs in formations where alternating competent and less resistant strata, such as interbedded phyllites and quartzites in the Snowshoe Group, are steeply dipping and oriented perpendicular to stream flow.

Relationships between placer deposits and hostrocks are commonly used by explorationists attempting to locate lode gold sources. Placer deposits have led to the discovery of some of the worlds largest gold mines (Stevens, 1983). For example, the morphology of gold particles can be used to estimate transport distance on the basis of surface modifications and the disappearance of primary crystal shapes (Herail *et al.*, 1990). An inverse relationship between gold size and transport distance is also known and has been demonstrated experimentally (Giusti, 1986; Minter 1991; Yeend, 1991). Size and shape analyses must be considered together, as finer and flatter gold grains are more easily entrained and are transported greater distances than larger, more spheroidal grains (Giusti, 1986; Minter *et al.*, 1993). Other factors such as rate of transport, bed conditions, gravel composition and gravel size distribution are also important (Yeend, 1991). An understanding of the depositional environment of a placer deposit, as well as gold particle size and morphologic studies, is necessary before inferences regarding the proximity of the original source rocks can be made, as the degree of grain modification varies with different processes of transport and deposition. For example, fine detrital gold in some fluvial systems can be transported many hundreds of kilometres from the original source whereas in other depositional environments, such as some alluvial fans, it may have been derived from lode sources immediately upslope from the placer deposit (Knight and McTaggart, 1990; Levson, 1991b). In contrast, coarse gold in most settings occurs in close to its hostrocks (Kartashov, 1971; Teeuw *et al.*, 1991). Knight and McTaggart (1990) found that although most placer gold in the Wells area can be related to known lode sources, at least two types of gold are derived from lodes yet to be discovered. Paleoflow analyses of auriferous placer deposits can also be used in the search for lode gold sources, particularly if coarse or angular gold are present or where sedimentological data indicate a

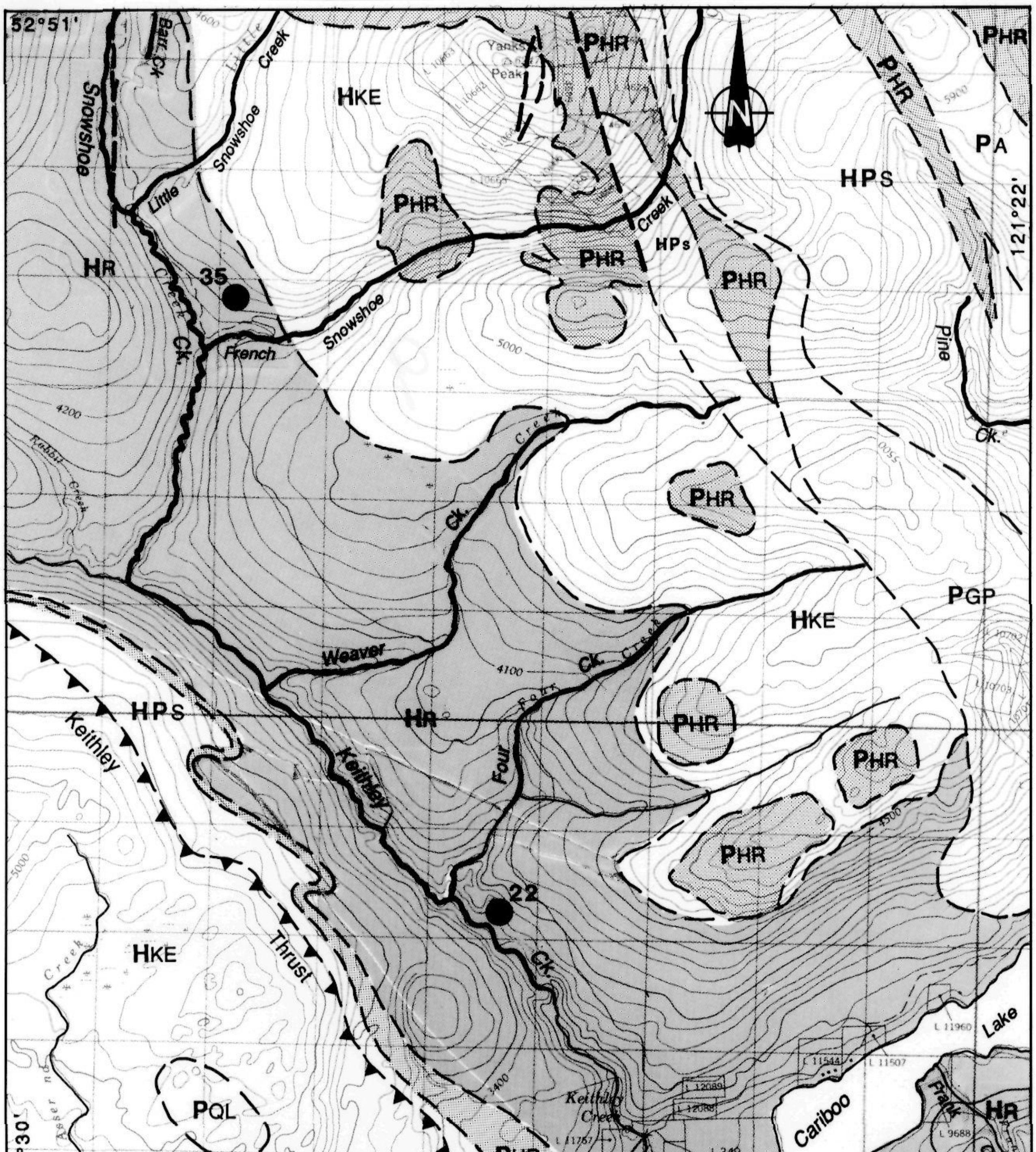


Figure 9. Bedrock geology, placer producing streams (heavy lines) and detailed study sites (solid circles) in the Keithley Creek area. Formations with known lode source potential are shaded (*see* common legend page 9).

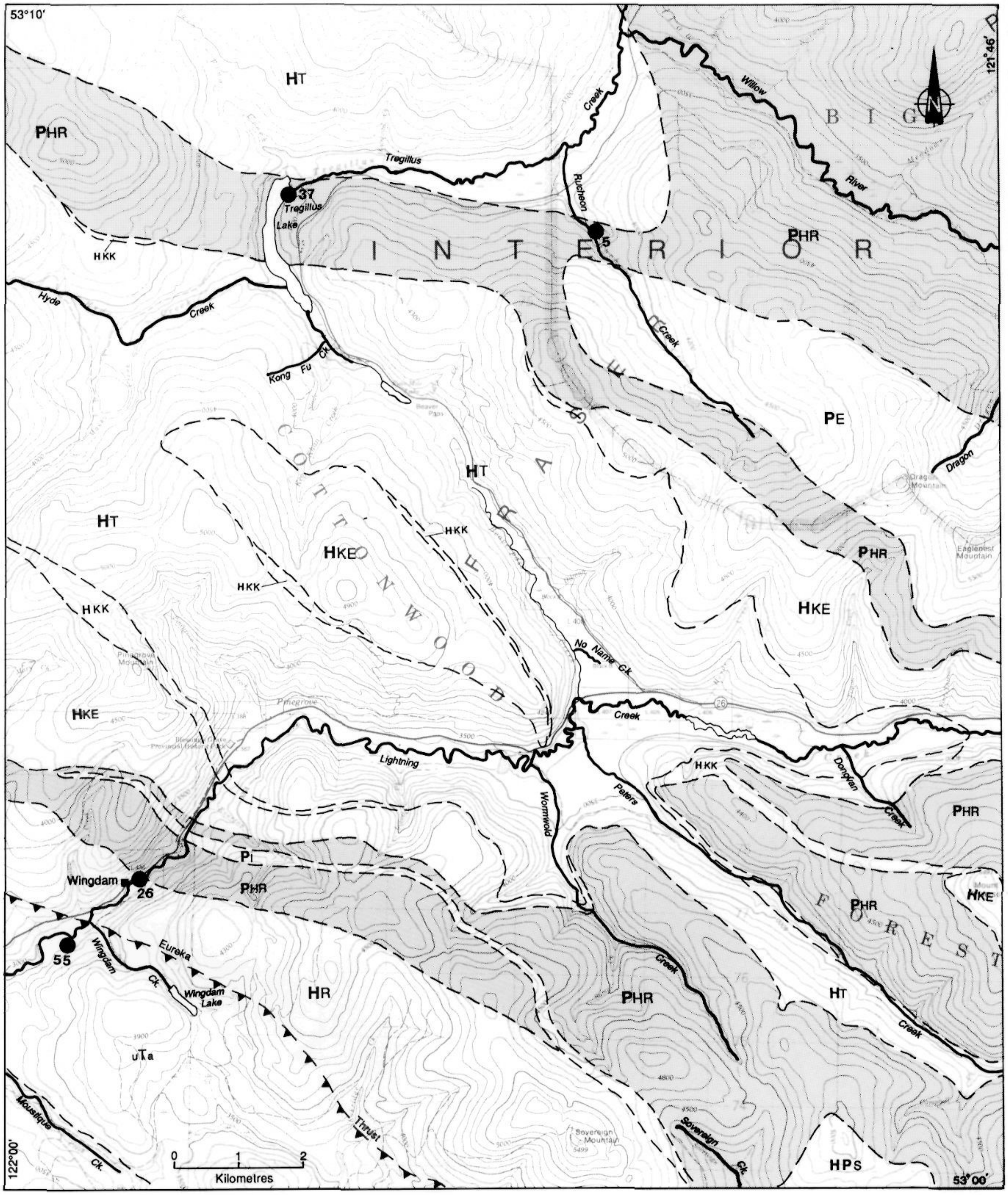


Figure 10. Bedrock geology, placer producing streams (heavy lines) and detailed study sites (solid circles) in the lower Lightning Creek and Tregillus Creek areas. Formations with known lode source potential are shaded (*see* common legend page 9).

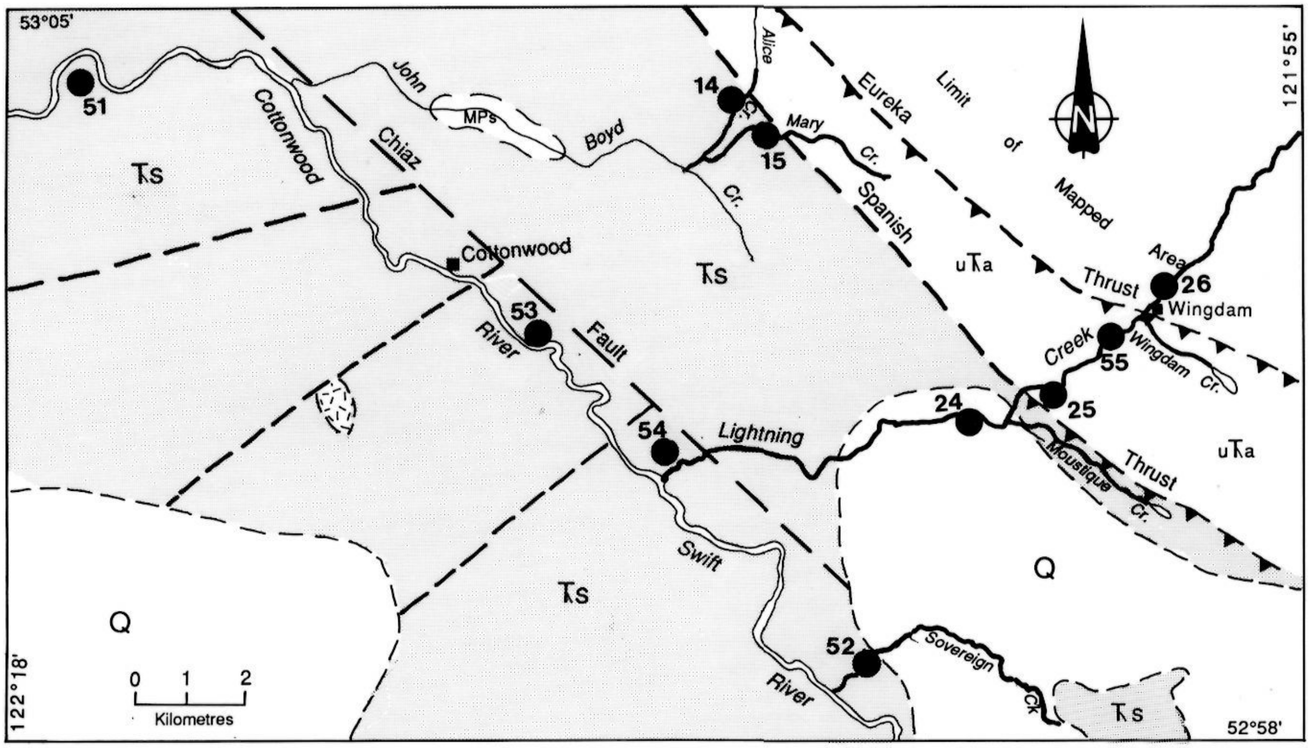


Figure 11. Bedrock geology, placer producing streams (heavy lines) and detailed study sites (solid circles) in the Cottonwood and Wingdam areas.

LEGEND

QUATERNARY

Q	Diamicton, gravel, sand, silt and clay

TERTIARY

Mvb	Miocene vesicular olivine basalt
MPs	Sandstone, shale, conglomerate, diatomite, lignite
Es	Eocene sandstone, mudstone and minor conglomerate

CRETACEOUS

Kgd	Hornblende granodiorite and quartz monzonite

JURASSIC

uJcg	Cobble conglomerate, mudstone and sandstone
Js	Siltstone and sandstone, massive to well bedded, commonly pyritic
Jb	Amygdaloidal, analcite-bearing, olivine basalt breccia and flows
lJvs	Volcanic breccia, tuff and tuffaceous siltstone and sandstone
	Syenite, monzonite and diorite; minor ultramafics, gabbro

TRIASSIC

uTa	Phyllite, argillite, quartzite, schist, minor greenstone
uTvs	Basaltic breccia, flows and pillow lava; minor sandstone and tuff
Ts	Sandstone, siltstone and shale; mafic volcanic and volcaniclastic interbeds
- - -	Geological Contact
— — —	Fault (Known or Inferred)
▲ ▲ ▲	Thrust Fault
•	Placer Sites Visited

Source:
Bailey, D.G. (compiler) 1990. Geology of the Central Quesnel Belt, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources, Geological Survey Branch*, Open File 1990-31; 1:100 000.

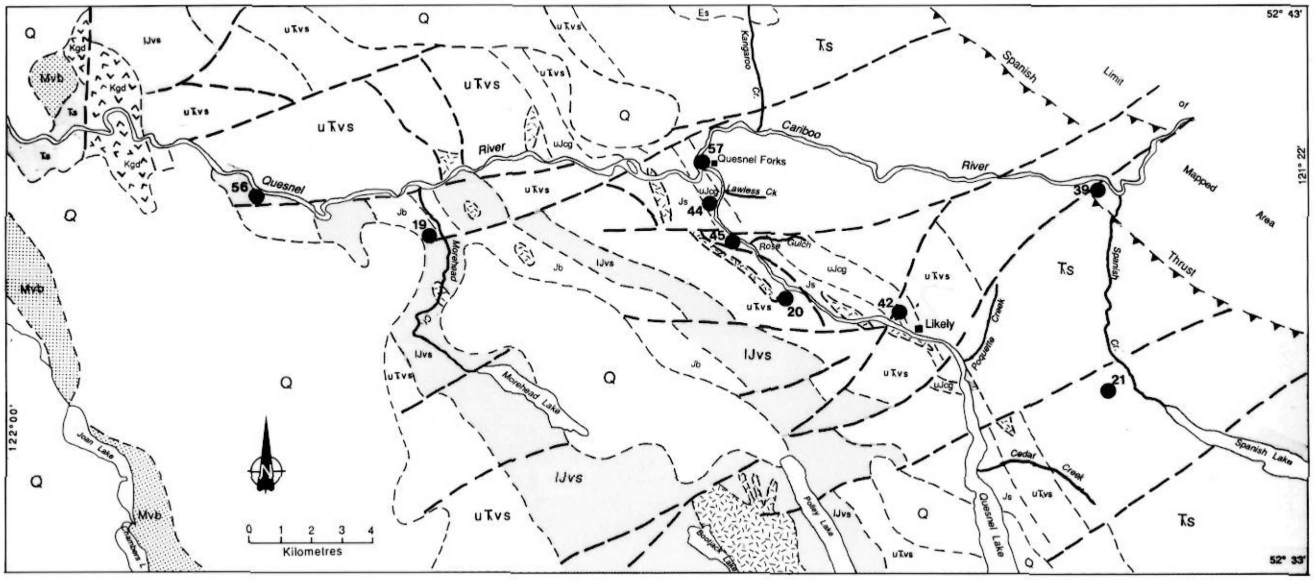


Figure 12. Bedrock geology, placer producing streams (heavy lies) and detailed study sites (solid circles) in the Quesnel Forks - Likely area (*see* Figure 11 for legend).

nearby origin as in some debris flow, paleogulch and alluvial fan deposits. Information relevant to determining proximity of lode sources is provided wherever possible in the property descriptions in Chapter 5.

GLACIAL CONTROLS ON GOLD PLACERS

Glaciation usually has the effect of decreasing placer productivity and it is generally assumed that in glaciated areas, most placer minerals were released from their bedrock sources during the Tertiary and, only to a lesser extent, during nonglacial or interglacial intervals of the Quaternary (Sutherland, 1985; Shilts and Smith, 1988). The Valdez Creek mine, Alaska's most productive gold mine, is a notable exception to this rule, with most of the gold coming from interglacial (Sangamonian) and interstadial (late Illinoian and mid-Wisconsinan) paleochannel deposits buried by till and other sediments (Smith, 1970, 1981; Bressler *et al.*, 1985; Hughes, 1989; Reger and Bundtzen, 1990). Much higher placer gold production in northeast Asia compared with northwestern North America has recently been attributed to more extensive glaciation in the latter resulting in the destruction, dilution and burial of placer deposits there (Bundtzen, 1991). Even in parts of Asia and North America (and other continents) glaciated during the Quaternary, the most productive placer deposits are invariably preglacial in age (Boyle, 1979).

Levson and Morison (in press) suggest several reasons why preglacial placers are more productive than interglacial or postglacial deposits. First, there was more time available for concentrating gold from bedrock by weathering and erosion during preglacial periods than during Quaternary interglacial or postglacial time. Second, processes of glacial and glaciofluvial erosion and redeposition generally result in dilution of the original placer concentrations by the net addition of nonauriferous, glacially derived debris. Also, as exposed areas of auriferous bedrock are susceptible to ice erosion, glaciation decreases the availability of easily erodable gold sources. Finally, paleoplacer deposits that do escape erosion during glaciation are commonly buried by glacigenic debris and difficult to locate. In spite of these difficulties, placer deposits in glaciated areas continue to be important commercial sources of gold and other heavy minerals.

Due to the erosive nature of glaciers and subglacial meltwaters, the distribution of placers in glaciated areas is generally highly discontinuous and exploration programs must focus on geologic settings with good placer preservation potential. In particular, preglacial placer deposits are best preserved in valleys oriented transversely or obliquely to the direction of regional ice flow or in sites in the lee of bedrock highs where glacial erosion was minimal. For example, preservation of a large placer deposit buried by till on Spanish Mountain near Likely (Location 21, Figure 2) was attributed to the oblique orientation of the deposit relative to the direction of ice flow. Based on determinations of glacial flow direction in the area, the placer deposit is also located in the lee of a large bedrock high. Paleochannel placer deposits in the Atlin area in northern British Columbia and in the Livingstone Creek area in central Yukon Territory are preserved along tributary streams oriented obliquely to the former ice flow direction of the main valley glaciers (Levson, 1992a, b). Similarly, in placer districts in the Appalachian Mountains, preservation of preglacial placer deposits occurred in valleys oriented transverse to the regional ice flow direction but many other deposits were destroyed during glaciation (Shilts and Smith, 1986, 1988).

Regions outside the main accumulation areas of past glaciers are also good areas for preservation of buried placer deposits because ice erosion is typically greater in the upper parts of mountain valleys or high mountainous regions than at lower elevations (Sutherland, 1985). For example, in the Atlin area, buried placers have been found only in the lower reaches of several valleys, till occurring directly on bedrock in the more heavily ice-eroded, upper parts of the valleys (Levson, 1992a; Levson and Kerr, 1992). Preservation of preglacial fluvial placers, in the Clear Creek (Morison, 1983a, b) and Mayo areas (Boyle and Gleeson, 1972) in central Yukon, has also been attributed to decreased subglacial erosion at these sites. In addition to a glaciologic influence, the lack of gold in the stagnant ice deposits that characterize the Clear Creek area (and preservation of the underlying placer gravels), was explained by the rarity of erosional events during their deposition (Morison, 1985).

Paleochannel placer deposits are also often preserved in areas where ice damming occurred in the early phases of glaciation, resulting in a rapid change from potentially erosive to mainly depositional conditions. Glaciolacustrine sediments are also clay rich and not readily eroded by overriding glaciers. Glaciolacustrine deposits are common in tributary valleys that remain ice free when glaciers begin occupying the adjacent main valleys. Where these tributaries are not inundated by local valley glaciers prior to the damming event, erosion of the placer deposits by glacial ice or meltwater is unlikely to occur. Exploration for other buried deposits should concentrate on geomorphic settings with similar glacial histories. Paleochannel placer deposits preserved in this type of setting have been described from numerous areas including Atlin (Levson, 1992a), Livingstone Creek (Levson, 1992b), the Cariboo (Levson, 1990; Levson and Giles, 1991) and Valdez Creek (Reger and Bundtzen, 1990). Placers that accumulated in the latter area during periods of low base level and channel incision, were buried and preserved by glaciolacustrine sediments deposited in ice-dammed lakes that formed as a result of differences in the timing and extent of main and tributary valley glaciers (Reger and Bundtzen, 1990).

CHAPTER 3 STRATIGRAPHIC AND SEDIMENTOLOGIC OVERVIEW

STRATIGRAPHY

The placer deposits studied in the Cariboo region occur in four major stratigraphic units (Figure 13): Tertiary, pre-Late Wisconsinan (pre-Fraser) Pleistocene (mainly interglacial), Late Wisconsinan (last glacial), and Holocene (postglacial) units. Although sedimentologic and geomorphic factors have also been used to classify each of the studied deposits, stratigraphic position is generally the most important geologic factor effecting potential productivity of the deposits. Specifically, the most productive placer deposits in the Cariboo are those that stratigraphically underlie till and other nonauriferous glacigenic sediments of one or more glaciations. They are usually preglacial or Tertiary in age but they also include some Pleistocene interglacial deposits. They are commonly directly overlain by at least a few metres of glaciolacustrine deposits or other fine-grained materials, possibly reflecting the influence of deformable sediments on the preservation of these older placers from glacial erosion.

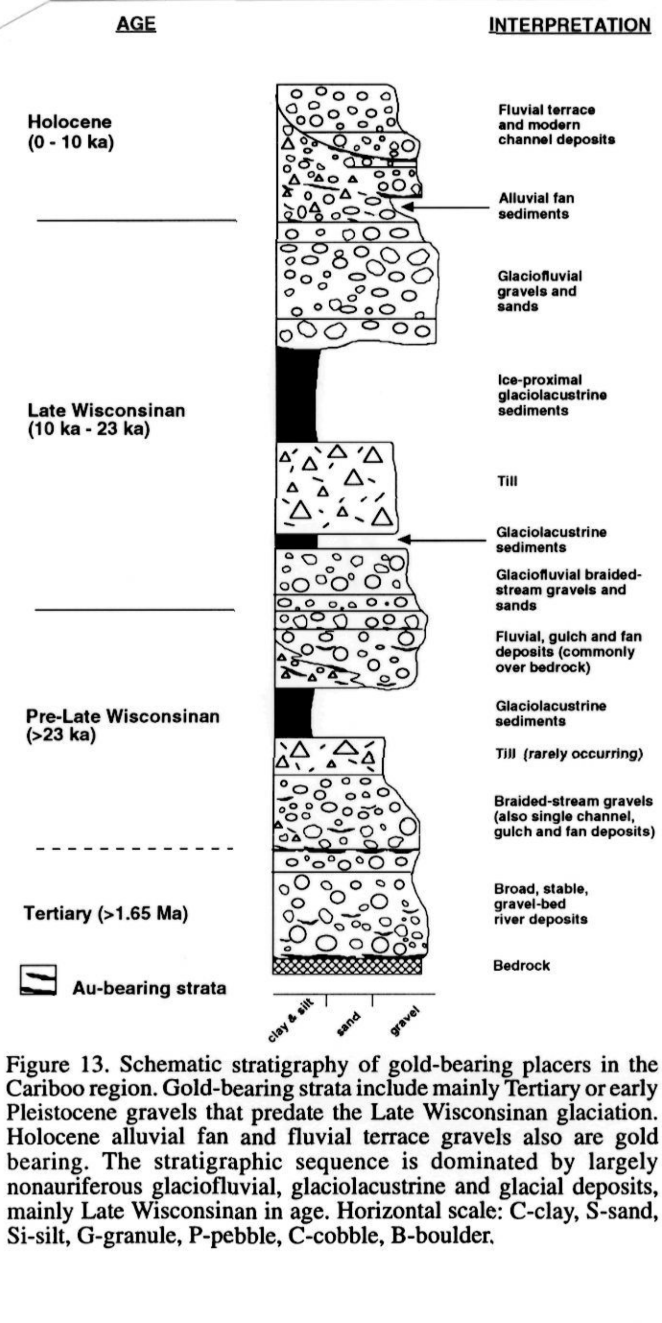


Figure 13. Schematic stratigraphy of gold-bearing placers in the Cariboo region. Gold-bearing strata include mainly Tertiary or early Pleistocene gravels that predate the Late Wisconsinan glaciation. Holocene alluvial fan and fluvial terrace gravels also are gold bearing. The stratigraphic sequence is dominated by largely nonauriferous glaciofluvial, glaciolacustrine and glacial deposits, mainly Late Wisconsinan in age. Horizontal scale: C-clay, S-sand, Si-silt, G-granule, P-pebble, C-cobble, B-boulder.

Most Tertiary placers studied in the Cariboo were deposited in broad, gravel bed, fluvial channels although locally they may have originated as debris flows or by other colluvial processes. They are typically overlain by many tens of metres of younger Tertiary and Quaternary sediments (Figure 13) and are exposed only in large, incised river valleys.

Pre-Late Wisconsinan Pleistocene placers include mainly fluvial, alluvial fan and fan-delta deposits. These deposits typically occur directly over bedrock and under surficial till (and associated glaciofluvial or glaciolacustrine deposits). In the absence of other data, the till is assumed to be Late Wisconsinan in age as the entire region was ice covered during the Fraser glaciation (Tipper, 1971; Clague, 1991). An unequivocal interglacial setting for these subtill deposits can rarely be established on the basis of stratigraphic data alone as they rarely occur between two till units; glacial deposits predating the Late Wisconsinan are recognized at only a few localities. Although a mid-Wisconsinan or Sangamonian age for these deposits is probable, at most localities a much greater age can not be definitively ruled out.

Placers of Late Wisconsinan age can be divided into till and glaciofluvial outwash deposits. Till of the last glaciation is stratigraphically overlain and underlain by both glaciolacustrine and glaciofluvial deposits (Figure 13). The thickness of these deposits varies from a few to several tens of metres. Mineable gold-bearing glaciofluvial deposits are almost always restricted to gravels stratigraphically overlying till (*i.e.*, gravels deposited during retreat, rather than advance phases of the last glaciation).

Holocene placers occur mainly as terrace deposits, colluvium and alluvial fan deposits. Occurring mainly in modern river valleys, they may overlie units of any age and are typically in unconformable contact with the underlying deposits. They are generally most productive where they directly overlie bedrock or older gold-bearing gravels.

TERTIARY PLACERS

Auriferous Tertiary gravels and conglomerates in the Cariboo typically unconformably overlie bedrock and are

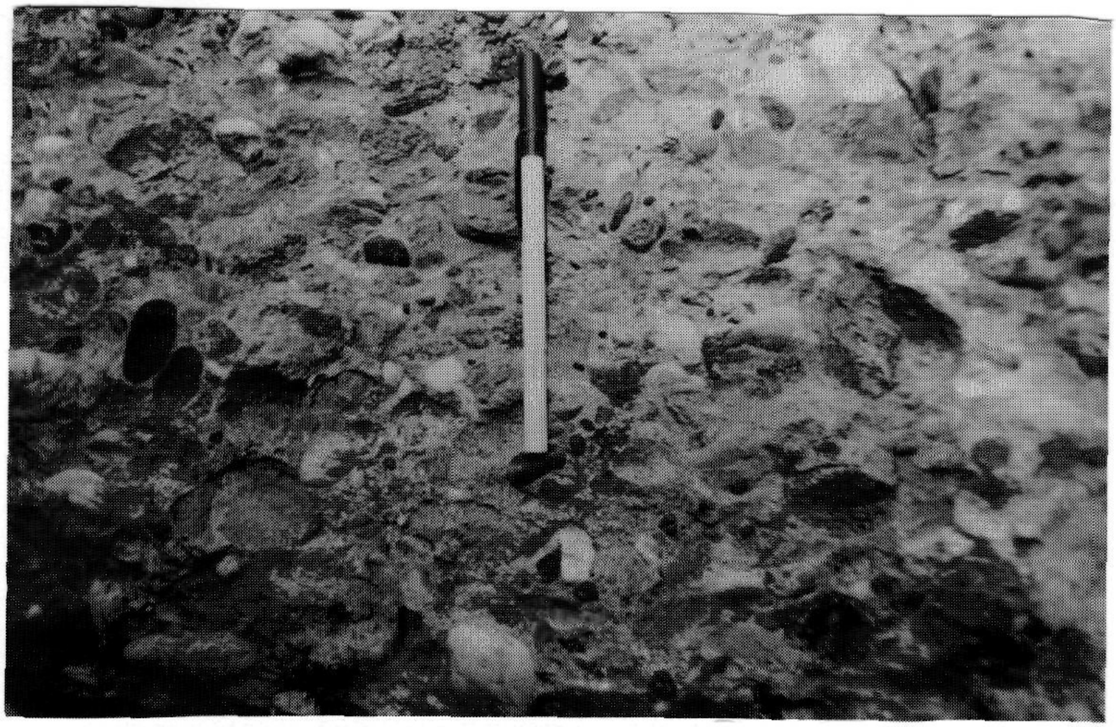


Plate 1. Gold-bearing Miocene conglomerate from the Horsefly River area (Location 4).

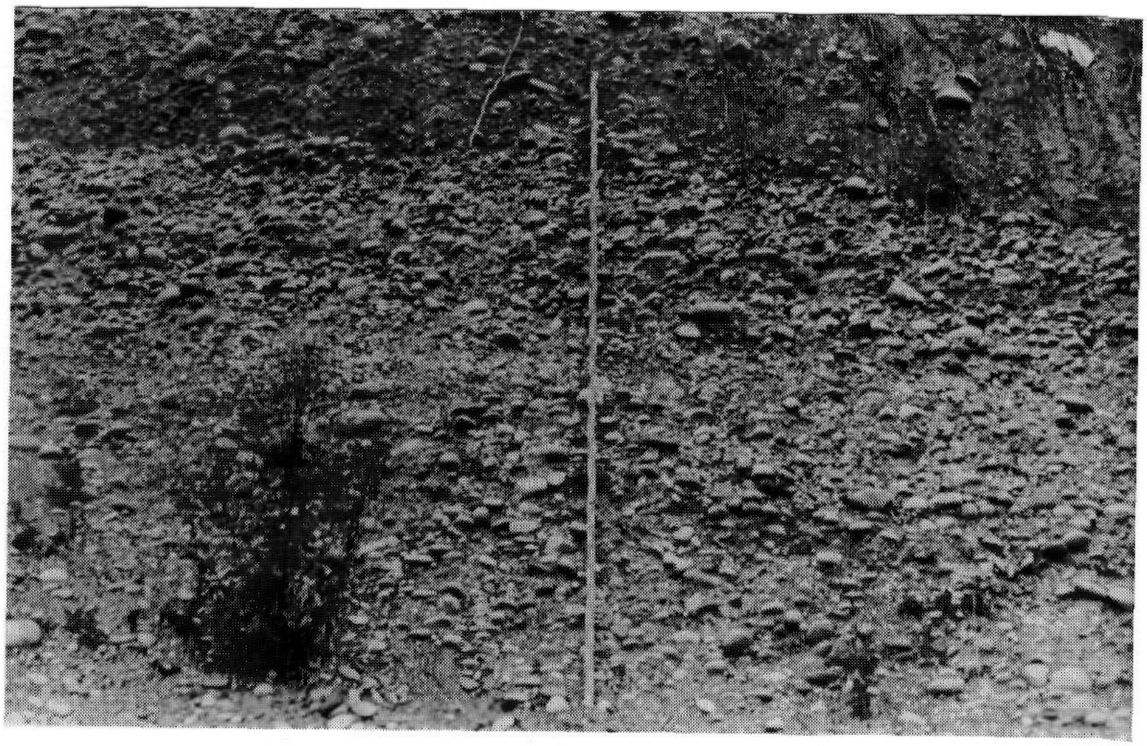


Plate 2. Imbricated, well-rounded quartzite and basalt gravel/conglomerate of probable Tertiary age along the Quesnel River (Location 1). Rod is 4 metres long.

stratigraphically overlain by several tens of metres of Quaternary deposits. They commonly are strongly cemented with iron and manganese oxides or calcite (Plate 1). The gravels are typically well stratified, well imbricated and well rounded (Plate 2). Dominance of resistant rock types such as quartzite, combined with the high degree of clast roundness, indicates relatively long periods of fluvial transport. Paleocurrent and lithologic provenance data commonly indicate significantly different drainage patterns in the Tertiary and the present. Chronologic control on these deposits is locally provided by K-Ar dates on interbedded basalts and tephras and by biostratigraphic data (pollen, leaf and fish fossils) from associated lacustrine deposits and fine-grained fluvial sediments. Rouse *et al.* (1990), for example, assigned a Tertiary age to a number of placer deposits in the Cariboo. Dating was based on the palynology of the sediments, principally the occurrence of *Cedrus perilata* which became extinct in North America in the Late Miocene, and the association of placers with volcanic clasts and ash that are generally limited to Tertiary successions. Gold deposited in many Tertiary streams occurs in low concentrations and is fine grained due the low gradient of the depositional systems. Tertiary gold-bearing gravels are also known from a few other glaciated areas in Canada such as the Chaudière valley in southeastern Quebec (Shilts and Smith, 1986, 1988).

Gold-bearing gravels of Tertiary or presumed Tertiary age have been mined in recent years at a number of sites in the study area (Figures 2 and 6; Locations 1 to 4). Tertiary deposits identified by Rouse *et al.* (1990) were associated with the late Tertiary Fraser Bend Formation. Gravel of the Fraser Bend Formation occurs at elevations below 600 metres along the Fraser River in a north-south belt that is at least 150 kilometres long and less than 27 kilometres wide (Rouse and Mathews, 1979). The basal 3 to 10 metres are dominated by well-rounded and imbricated quartzite and quartz clasts up to 30 centimetres in diameter, with some smaller chert clasts. At the type locality about 10 kilometres northwest of Quesnel, the basal gravel is overlain by 55 metres of finer and less well sorted and rounded chert-rich gravel with some lignite fragments and 90 metres of clay and fine gravel with scattered sandy and silty layers (Rouse and Mathews, 1979).

Recent and historical mining of cemented placer gravel has been concentrated along the Fraser River valley north of Quesnel. From fossil evidence, moderately well cemented gravels overlying bedrock in this area are inferred to be Tertiary and may be correlative with gravel of the Fraser Bend Formation (Rouse and Mathews, 1979) and possibly also with cemented gravels in the Big Canyon area (Figure 14A, B; Location 1, Figure 2). Tertiary gravels in this area are confined to a channel-like feature by bedrock highs. Although the main gold-bearing strata occur below river level, several metres of the gravel (Figure 14B) are well exposed above the low water line (about 510 metres) at the Allstar mine on the west bank of the Fraser River (Figures 2 and 6, Location 2). The gravels contain up to 8.5 grams of gold per tonne in the lowermost pay zones. At the base of the section, up to 50 centimetres of sand, containing abundant fossil plant fragments, are overlain by cemented pebble gravel with some cobbly beds. The gravel is massive to crudely stratified and coarser beds have scoured lower contacts (Plate 3). Trough-crossbedded sand and gravel lenses and horizontally laminated silt lenses are also present. Wood, at various stages of petrification, and coal fragments are common throughout the gravel succession. The gravels are interpreted as wandering gravel-bed channel deposits with interbedded, sandy bar and overbank sediments.

Texturally mature gravel, believed to be Tertiary in age, and at least two other stratigraphically younger gravel units (Figure 14A), have been identified along the Big Canyon portion of the Quesnel River (Figures 2 and 6, Location 1; Figure 15). The lowest gravel exposed (Figure 16, Unit 2) consists of well-rounded quartzite, chert and volcanic clasts. At the base they are strongly cemented with iron and manganese oxides (Plate 4). Paleocurrent and lithologic provenance data indicate a substantially different drainage pattern to that of the present river. Pebble imbrication data from three different sites (Locations J, A/B and H on Figures 15 and 16) indicate an easterly flowing system (Figure 17) in contrast to the present westerly flow. Major differences between Tertiary and modern drainage patterns along the Fraser and Quesnel rivers were first discussed in detail by Lay (1940, 1941) but no comprehensive regional study has been conducted since then. Postglacial terrace gravels, unconformably overlying the older gravel units (Figure 16), are currently being mined, but Tertiary gravels are not worked at this location due to their induration. Much of the placer gold in the region is believed to have been reconcentrated from the cemented preglacial gravels by younger river systems.

In the Horsefly area (Figures 2 and 6), Miocene gravels have been mined since the start of the Cariboo gold rush in the 1850s, their age determined by bracketing K-Ar dates on volcanic rocks. The gravels are underlain by a thick succession of horizontally laminated Eocene lacustrine sediments containing abundant fossil insects, leaves, diatoms and fish dated at 45 to 50 Ma (Wilson, 1977). At the Hobson Horsefly mine north of Horsefly townsite (Figures 2 and 6, Location 4; Figure 14C), the Miocene gravel is 3 to 10 metres thick. The auriferous gravels are overlain by more than 25 metres of overburden and consequently they have been mined underground in recent years (Plate 5). Gold occurs mainly in calcite-cemented pebble gravels in the lower part of the sequence. Textural maturity of the gold-bearing gravels, which consist mainly of quartzite, vein quartz, chert and basalt pebbles, indicates deposition in a well-developed fluvial system.

The deposits overlying the auriferous gravel at the Hobson mine consist of a succession of interbedded sandy, small to large-pebble gravel and partially cemented medium to large-pebble and cobble-gravel beds. The gravel is mainly horizontally bedded and exhibits some large-scale trough crossbeds (Plate 5). They are inferred to be glaciofluvial in origin and were probably deposited in an aggradational, well channelled, proglacial braided river system. They grade upward into a few metres of matrix-supported diamic-

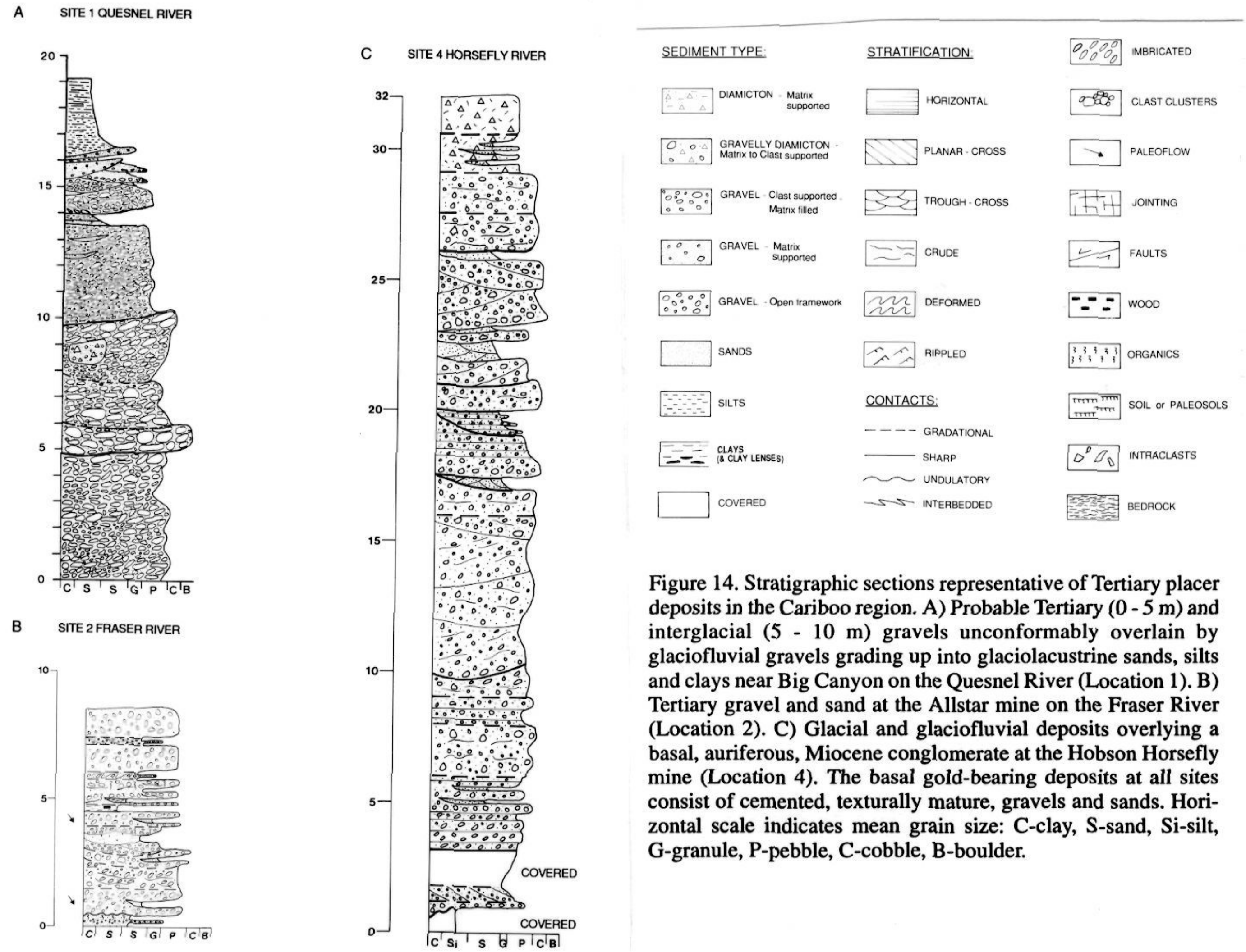


Figure 14. Stratigraphic sections representative of Tertiary placer deposits in the Cariboo region. A) Probable Tertiary (0 - 5 m) and interglacial (5 - 10 m) gravels unconformably overlain by glaciofluvial gravels grading up into glaciolacustrine sands, silts and clays near Big Canyon on the Quesnel River (Location 1). B) Tertiary gravel and sand at the Allstar mine on the Fraser River (Location 2). C) Glacial and glaciofluvial deposits overlying a basal, auriferous, Miocene conglomerate at the Hobson Horsefly mine (Location 4). The basal gold-bearing deposits at all sites consist of cemented, texturally mature, gravels and sands. Horizontal scale indicates mean grain size: C-clay, S-sand, Si-silt, G-granule, P-pebble, C-cobble, B-boulder.

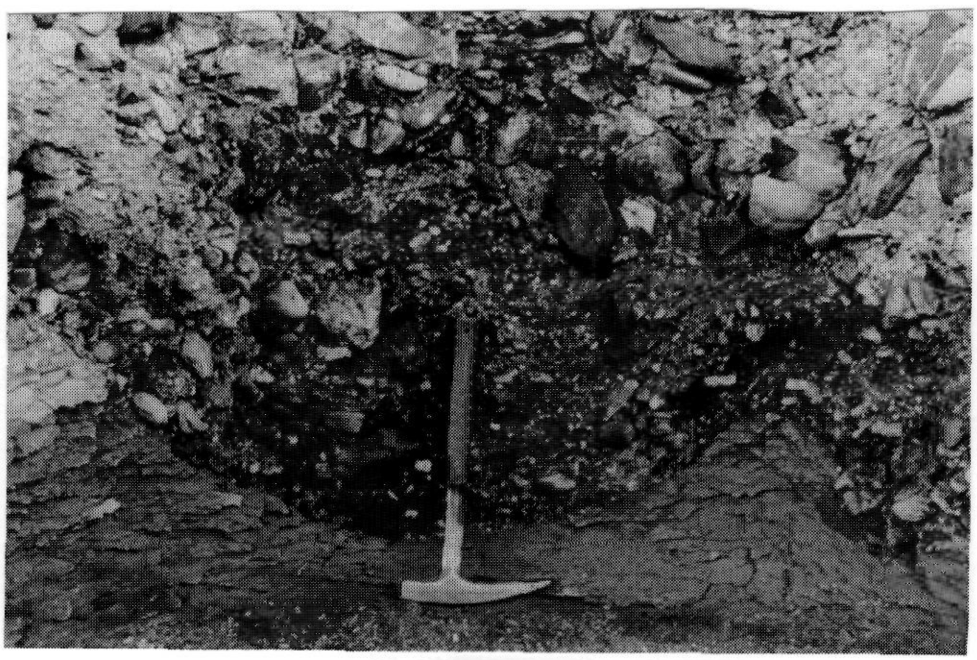


Plate 3. Unconformable, scoured contact between partially cemented, Tertiary (?) gravel and sand beds along the Fraser River near the Allstar mine (Location 2). The gravels contain petrified wood and coal fragments and are interpreted as gravel-bed channel deposits with interbedded, sandy bar and overbank sediments.

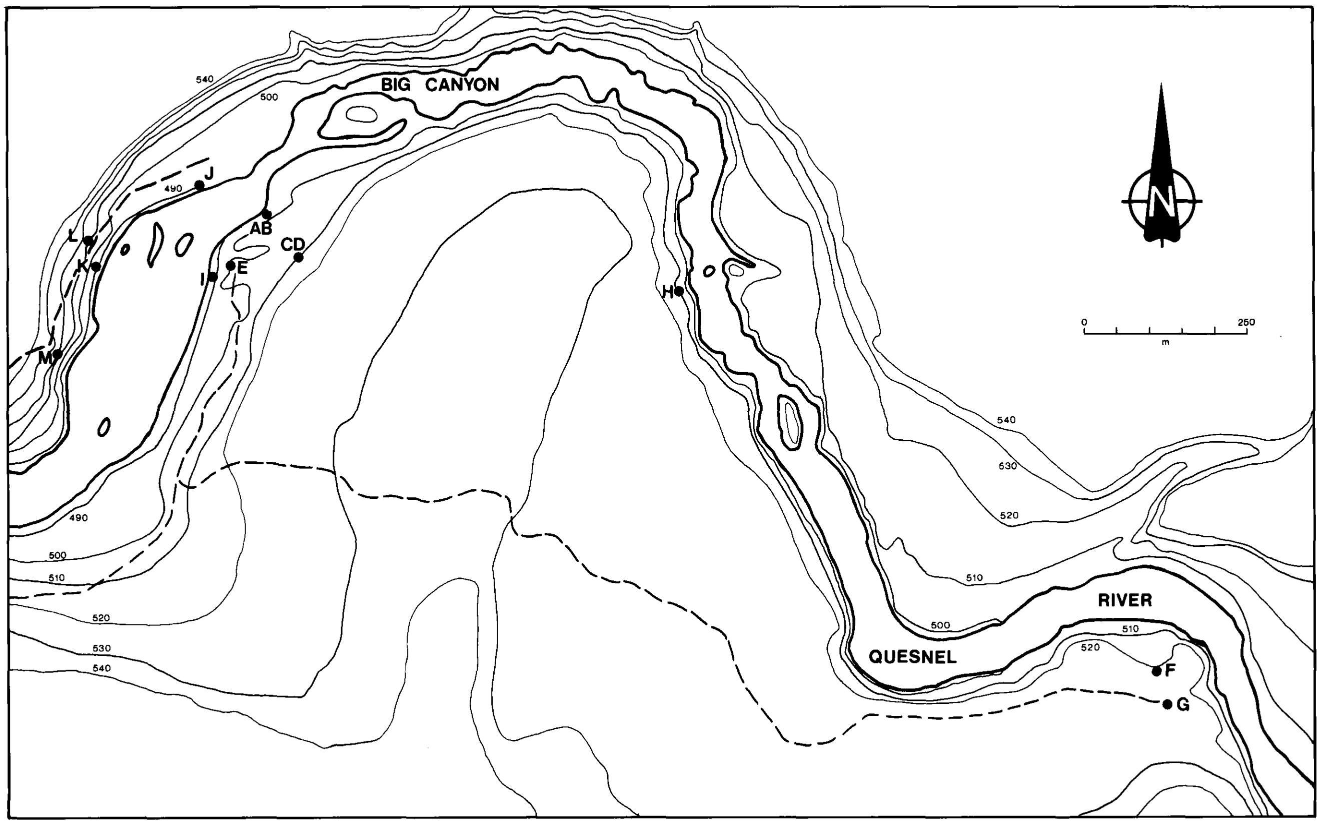


Figure 15. Location map of the Big Canyon area on the Quesnel River and locations of measured sections (*see* sites 1 and 48).

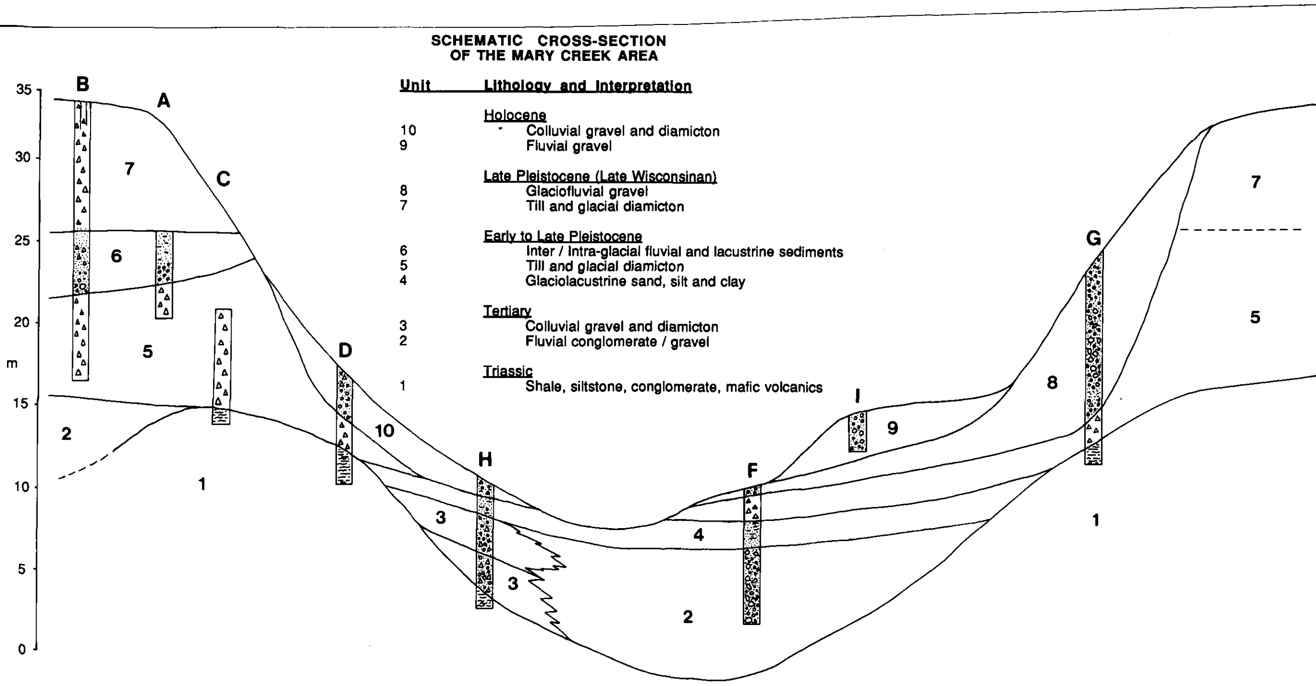


Figure 16. Interpretive geologic cross-section of the Quesnel Canyon area (Locations 1 and 48). Gold occurs mainly along unconformities at the base of Tertiary (Unit 2) and Holocene (Unit 8) fluvial gravels and to a lesser extent in Units 3, 6 and 7. Relative topographic positions of each section are accurately shown; horizontal positions are schematic. (Capital letters refer to locations of measured sections shown on Figure 15). Stratigraphic correlations are indicated with solid lines.

Plate 4. Texturally mature conglomerate, believed to be Tertiary in age, along the Big Canyon portion of the Quesnel River (Location 1). The conglomerate is cemented with iron and manganese oxides and forms resistant benches.

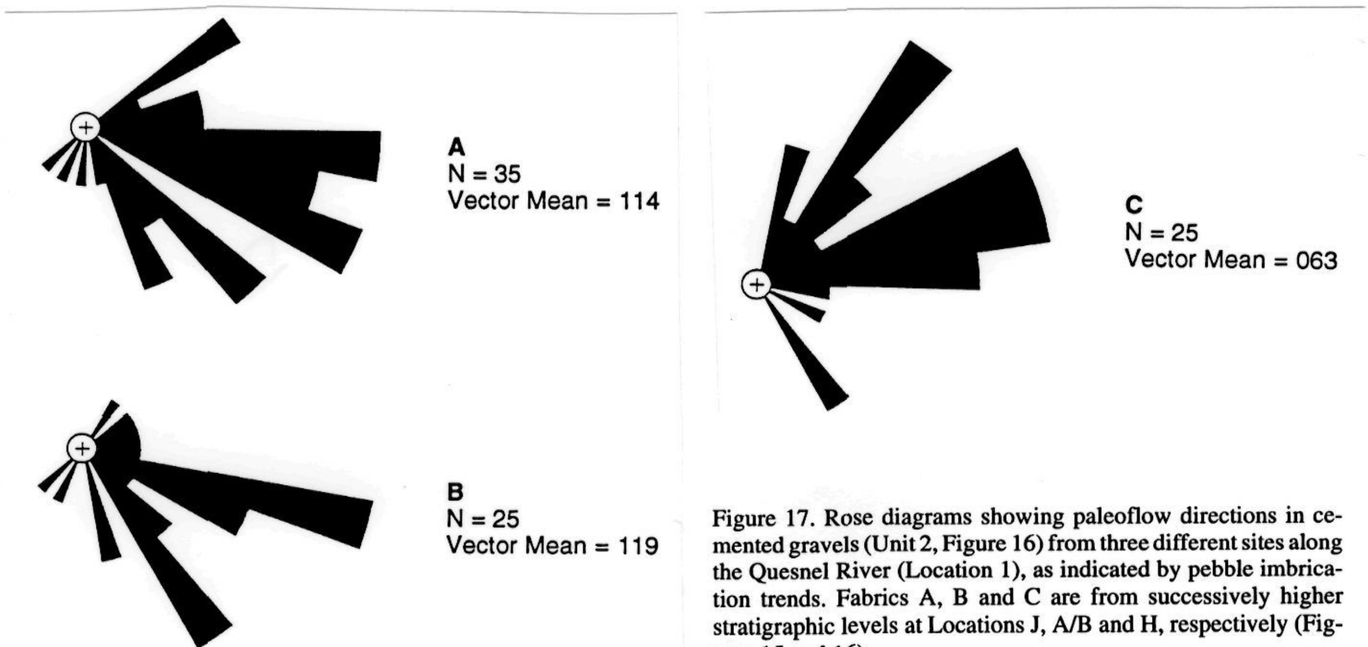


Figure 17. Rose diagrams showing paleoflow directions in cemented gravels (Unit 2, Figure 16) from three different sites along the Quesnel River (Location 1), as indicated by pebble imbrication trends. Fabrics A, B and C are from successively higher stratigraphic levels at Locations J, A/B and H, respectively (Figures 15 and 16).

Plate 5. Underground mine in auriferous Miocene gravels north of Horsefly townsite (Location 4). The 25-metre thick overburden sequence consists of horizontally bedded, sandy, small to large-pebble gravels with interbedded, large-pebble to cobble gravels at the base of broad, trough-shaped units. They are interpreted as glaciofluvial gravels deposited in aggrading, braided stream channels. A few metres of glacigenic diamicton of Late Wisconsinan age caps the exposure.

ton with clasts up to boulder size, probably glacial in origin and inferred to be Late Wisconsinan in age.

PRE-LATE WISCONSINAN (INTERGLACIAL) PLACERS

A large number of placer deposits mined in the Cariboo, stratigraphically underlie till of the last (Late Wisconsinan) glaciation (Figures 2 to 4; Locations 5 to 31). Precise dating of these sediments is usually not possible as they are beyond the limits of radiocarbon dating. Some of these deposits may be preglacial or Tertiary in age but most are believed to be Pleistocene interglacial or interstadial deposits as indicated by the presence of erratics and the lower textural maturity compared with similar gravel of known Tertiary age. A few finite radiocarbon dates have recently been obtained from Middle Wisconsinan interstadial sediments (Clague *et al.*, 1990) but such dates are rare due to the typical absence of organics in placer gravel sequences. The coarse nature of most placer deposits precludes good preservation of pollen and volcanic ash, limiting the usefulness of palynological and radiometric dating techniques.

Although British Columbia was glaciated repeatedly during the Pleistocene, sediments predating the Late Wisconsinan Fraser Glaciation occur at many sites. Studies of pollen collected from interstadial sediments near the centre of the Cordilleran ice sheet in the Mexican Hill and Bullion mine areas indicate ice-free conditions in a radiocarbon dated interval from 40 000 to over 51 000 years ago (Clague *et al.*, 1990). Paleoplacers in a few areas are also buried by till and ice-stagnation deposits of the penultimate glaciation (Clague, 1991).

The stratigraphic complexities of preglacial and interglacial gravel sequences are illustrated by a succession of distinct gravel units, exposed along the Quesnel River (Figure 2, location 1). Gravels unconformably overlying bedrock (Figure 16, Unit 2) are dominated by cemented, well-rounded clasts of resistant lithologies. Overlying gravel (Unit 3) shows greater lithologic diversity, contains diamicton intraclasts and may be interglacial in age (Figure 14A; Plate 6). The uppermost gravels (Unit 4, Figure 16), which are overlain by glaciolacustrine deposits (Unit 5), are similar to other glaciofluvial gravels in the area. Gravels unconformably overlying Units 1 to 5, are interpreted as postglacial fluvial deposits (Units 6, 7 and 8, Figure 16).

LATE WISCONSINAN PLACERS

Placers occurring in sediments deposited directly by glacial ice or by meltwaters flowing near Late Wisconsinan glaciers, have been observed at only a few localities in the Cariboo (Figures 2 to 4, Locations 32 to 39). Economic gold concentrations in till and glacial outwash deposits are restricted to rare sites where ice or glacial meltwaters have eroded pre-existing relatively rich fluvial placers or host-rocks. Thickness of overburden is an important limiting factor in the exploitation of these typically low-grade deposits and, without exception, they are mined at sites where they occur near the surface with little or no overburden. For this reason, glacial or glaciofluvial placer deposits, associated

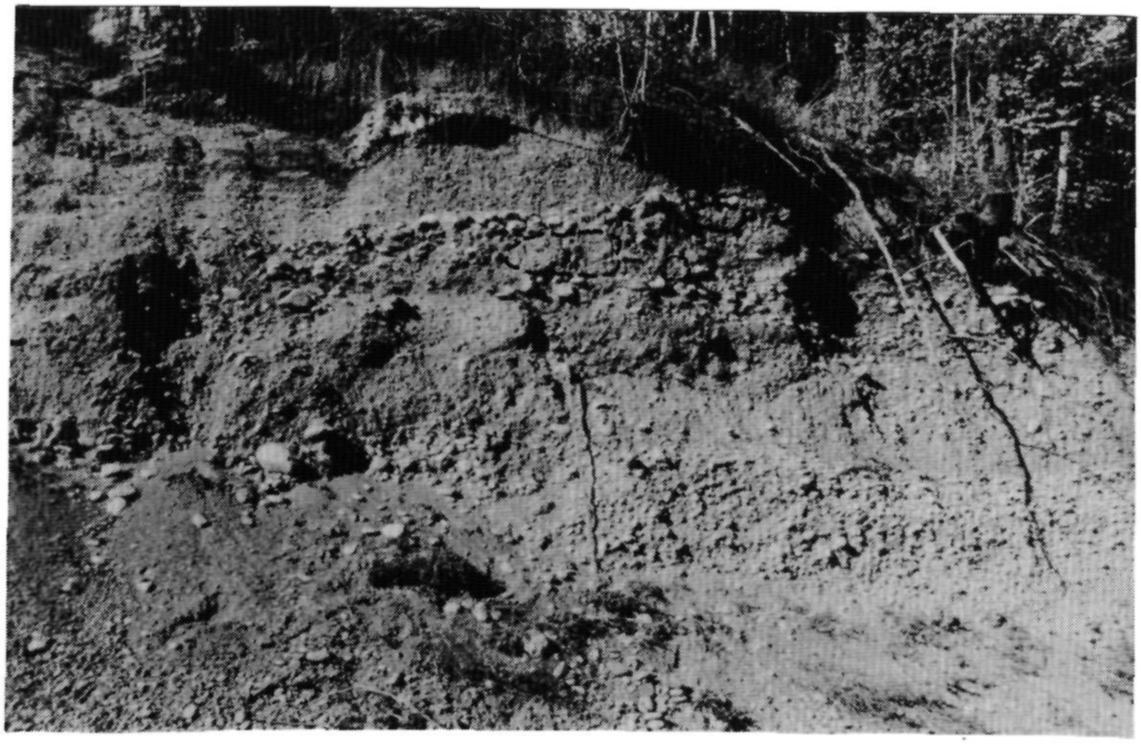


Plate 6. Quartz-rich, preglacial, conglomerate/gravel (lower white unit) overlain by lithologically diverse, interglacial gravels with diamicton intraclasts (outlined) along the Quesnel River. The upper gravels are interpreted as glaciofluvial deposits and they are overlain by glaciolacustrine sediments. Measuring rod is 4 metres long.

with stratigraphically older (pre-Late Wisconsinan) glacial events, are not mined in the Cariboo. Auriferous glacial and glaciofluvial deposits are also rare in other mountainous placer districts in glaciated areas such as the Andes where they occur only where middle and upper Pleistocene glaciers eroded primary mineralized zones (Herail *et al.*, 1989a). Similarly, in the Reefton area of New Zealand, auriferous glaciofluvial gravels occur only where late Pleistocene erosion of gold-bearing source rocks occurred (Pizey, *1991*). Gold was reworked from tills by glaciofluvial streams close to the ice margins and was further concentrated by postglacial streams (Williams, 1974).

Late Wisconsinan tills and glaciofluvial deposits occur as surface or near-surface deposits throughout the study area. Lodgement and melt-out tills are often separated from older deposits by a sharp erosional unconformity. Both advance and retreat phase glaciofluvial deposits occur in the region but, due to overburden constraints, most mineable deposits are deglacial in age. The latter mainly include meltwater channel deposits and terrace-top gravels capping thick valley-fill glaciofluvial sequences.

HOLOCENE (POSTGLACIAL) PLACERS

Although most of the productive placers in British Columbia formed in preglacial or interglacial times, economic postglacial placers also occur at a large number of locations (sites 40 to 61, Figures 2 to 4). Holocene placer deposits occur in a variety of depositional environments including high-gradient single channel (gulch), braided stream, meandering stream, alluvial fan and colluvial environments. Mines exploiting Holocene alluvial and colluvial placers are invariably developed in the vicinity of older fluvial deposits where gold has been concentrated by recent processes that have partially or totally reworked the pre-existing placers. Exceptions include large incised river valleys, such as the Fraser River, where generally fine-grained placer minerals (allochthonous placers of Kartashov, 1971) are found in modern alluvial deposits (*e.g.*, point bars) and Holocene terrace sequences. The period of time since deglaciation, and the amount of erosion of auriferous bedrock, seems to have been inadequate in most areas to allow for the formation of economically viable placers derived primarily from bedrock sources.

Gulch gravels were the most productive, accessible and easily mined postglacial Cariboo placers and few remained beyond the turn of the century. Floodplain and low-terrace deposits were also largely mined out in the 1800s, particularly in areas close to original source rocks where relatively coarse gold was recovered. Comparatively fine gold, however, that has been carried many kilometres downstream, is still mined in some regions. In addition, high-terrace gravels of probable early Holocene age are locally productive. Postglacial colluvial and alluvial fan placers are also mined locally.

SEDIMENTOLOGY OF GOLD-BEARING LITHOFACIES

Detailed descriptions of the sedimentology of Cariboo placers are provided in the following chapters but a brief summary of the most common gold-bearing lithofacies and some of the main sedimentologic controls on gold distribution is provided here. Five main auriferous lithofacies, distinguished by differences in grain size and sedimentary structures, are recognized. In order of decreasing importance these include (with inferred depositional environments): a) massive to crude, sub-horizontally stratified gravel with weak imbrication (shallow, gravel-bed stream deposits; mainly channel lag and longitudinal bar deposits); b) clast-supported, matrix-filled gravel and gravelly diamicton with coarse clast-clusters (hyperconcentrated floodflow and noncohesive debris-flow deposits); c) large-scale, trough crossbedded gravels (channel-fill deposits); d) planar crossbedded gravels (transverse bar deposits); and e) massive, fine-grained, matrix-supported diamicton (cohesive debris-flow deposits).

MASSIVE TO CRUDELY STRATIFIED GRAVELS

The most common auriferous lithofacies consists of a crudely imbricated, massive or horizontally stratified, clast-supported, pebble to cobble gravel (Plates 7 and 8). These gravels are mainly moderately to well rounded and of mixed provenance, including numerous clasts of local bedrock. They commonly unconformably overlie waterworn bedrock and are usually only a few metres thick. They are locally interbedded with sandy lenses, iron oxide stained small-pebble lenses and thin (up to a few clasts thick) open-work gravel beds, and occasional poorly sorted gravelly diamicton beds. Stratification, imbrication, clast rounding and the incorporation of local bedrock in the pay gravels all indicate fluvial transport and deposition in high-energy erosive systems, probably during and shortly after the final phases of channel degradation. Matrix-filled beds are strongly bimodal with the matrix deposited by infiltration after deposition of the framework gravels.

A few subfacies are recognized, based on variations in sedimentary structures. Crude horizontal bedding is typical of longitudinal bars and diffuse gravel sheets, common in gravelly braided streams (Hein and Walker, 1977; Hein, 1984). The most productive gold-bearing subfacies consists of coarse, commonly openwork, gravel beds occurring along trough-shaped unconformities. They are interpreted as lag concentrations developed as a result of significant channel erosion events. Gravels with large rounded boulders up to a few metres in diameter have particularly high gold contents (up to 150 grams per cubic metre). In analogous braided stream deposits in the Witwatersrand paleoplacers, Smith and Minter (1980) also found that gold was most concentrated on scour surfaces and in the matrix of well-sorted conglomerate beds. A relationship between high gold concentrations and coarse gravels in most fluvial deposits has long been known (Faizullin, 1969; Teeuw *et al.*, 1991).

Gravels of this facies typically have the highest gold concentrations where they overlie bedrock; elsewhere they commonly contain little or no gold. The latter, predominantly nonauriferous gravels, are horizontally stratified and

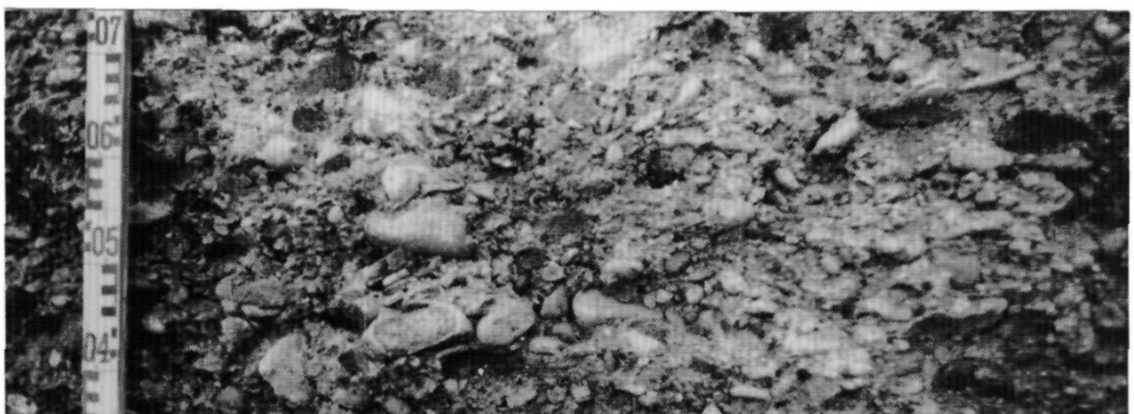


Plate 7. Massive to crudely stratified gravel facies at the Hobson mine (Location 4) exhibiting weak imbrication. Gravels of this facies are mainly clast supported and matrix filled although thin, open work gravel lenses occur. (Scale numbered every 10 centimetres).

are typical of longitudinal bar gravels deposited by aggrading braided streams in glaciofluvial environments.

POORLY SORTED GRAVELS AND GRAVELLY DIAMICTON

Clast-supported, poorly sorted gravels and gravelly diamicton comprise the second most common gold-bearing lithofacies. They exhibit a polymodal grain-size distribution ranging from fine sands to large boulders, although locally they are matrix supported and contain enough silt to be regarded as diamicton (Plates 8 and 9). Clasts vary from subangular to subrounded and may exhibit a weak a-axis imbrication. Two subfacies are differentiated by the presence of either rare normal grading or coarse clast-clusters (usually with imbricated cobbles 'stacked' on the upstream side of boulders and pebbly beds in the lee of the cluster). Gold is commonly dispersed throughout individual beds but is most concentrated around boulder clusters and in the lower parts of beds.

Plate 8. Crudely stratified gravel beds (upper half) overlying poorly sorted gravel and gravelly diamicton. Note the crude imbrication and scoured lower contact in the upper gravels, indicating turbulent flow. The more chaotic fabric and higher matrix content in the lower unit is indicative of debris-flow deposition. (Paleoflow from left to right.)

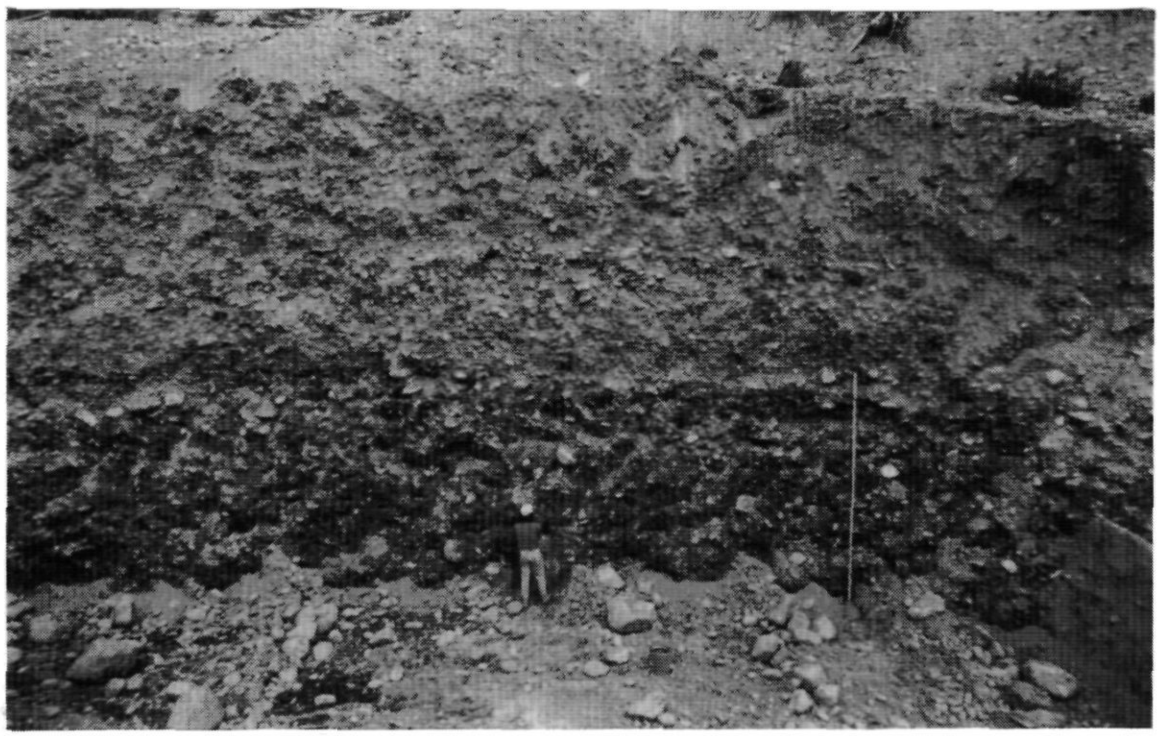


Plate 9. Gold-bearing deposits at the Gallery Gold mine along Lightning Creek (Location 24). Poorly sorted, gravel and gravelly damicton lithofacies, interpreted as noncohesive debris-flow deposits, at the base of the section are overlain by crudely stratified, massive gravels (*see* Plate 8 for details). The auriferous deposits overlie bedrock and contain up to approximately 75 grams of gold per cubic metre in the lower 2 to 5 metres. Measuring rod is 4 metres long.

Deposits of this type form in flows with rheologic properties intermediate between fully turbulent stream flows and cohesive debris flows or mud flows (Shultz, 1984; Postma, 1986; Smith 1986, 1987; Scott *et al.*, 1992). Rheologic variations in these gravelly flows mainly reflect varying sediment concentrations and differences in the relative proportion of water and fines, especially clay. The massive ungraded structure of most beds, particularly those with a sandy matrix, is typical of gravelly, noncohesive debris-flow deposits described by numerous authors and may be due to partial turbulence and/or rapid sedimentation rates at the time of deposition (Hein, 1984; Burgisser, 1984; Nemec and Steel, 1984; Wells, 1984). Sandy gravel beds with normal grading may have been deposited by combined tractional and suspension sedimentation in hyperconcentrated flood flows (Smith, 1986, 1987). Normal grading, in beds with more fines in the matrix, may also develop in pseudoplastic debris flows with water contents sufficiently high to allow clast settling (Shultz, 1984). Imbricated clast clusters in some beds indicate more turbulent conditions. Tractional deposition of large clasts occurs on the stoss side of boulders that form flow obstacles, and wake accumulations of finer gravels occur in the lee of the clusters (Brayshaw, 1984).

The common interbedded association of this facies with fluvial sands and gravels indicates episodic deposition within stream channels. The well-sorted and stratified gravel and sand interbeds represent more typical fluvial deposits whereas poorly sorted massive gravel and diamicton beds were probably deposited by sediment-rich, flood flows and debris flows.

The high-energy flows responsible for deposition of these lithofacies were probably associated with unusual flood conditions. Their typical occurrence on bedrock at the base of alluvial sequences suggests that they were deposited during or immediately after the most erosive events that occurred prior to valley aggradation. Gold that had previously accumulated on the channel floor must have been temporarily incorporated in the flow before redeposition. Gold is widely dispersed throughout the deposits suggesting that the flows were partially turbulent but settling of gold particles must have occurred at the time of deposition as gold concentrations are invariably highest at the base.

TROUGH AND PLANAR CROSSBEDDED GRAVELS AND SANDS

Productive gold-bearing gravels with well-developed trough or, particularly, planar crossbedding are relatively uncommon in Cariboo placers. Beds are moderately to well sorted and clast supported with either a sandy matrix or an open framework (Plate 10). Clasts are generally rounded to well rounded and exhibit b-axis imbrication. Gradationally interbedded massive gravels and cross-stratified sands are common. Trough crossbedded units typically fine upwards; lower contacts are scoured and marked by coarse gravel lags (Plate 10).

Crossbedding, clast imbrication, pebble roundness and good sorting all indicate deposition in a fluvial environment.

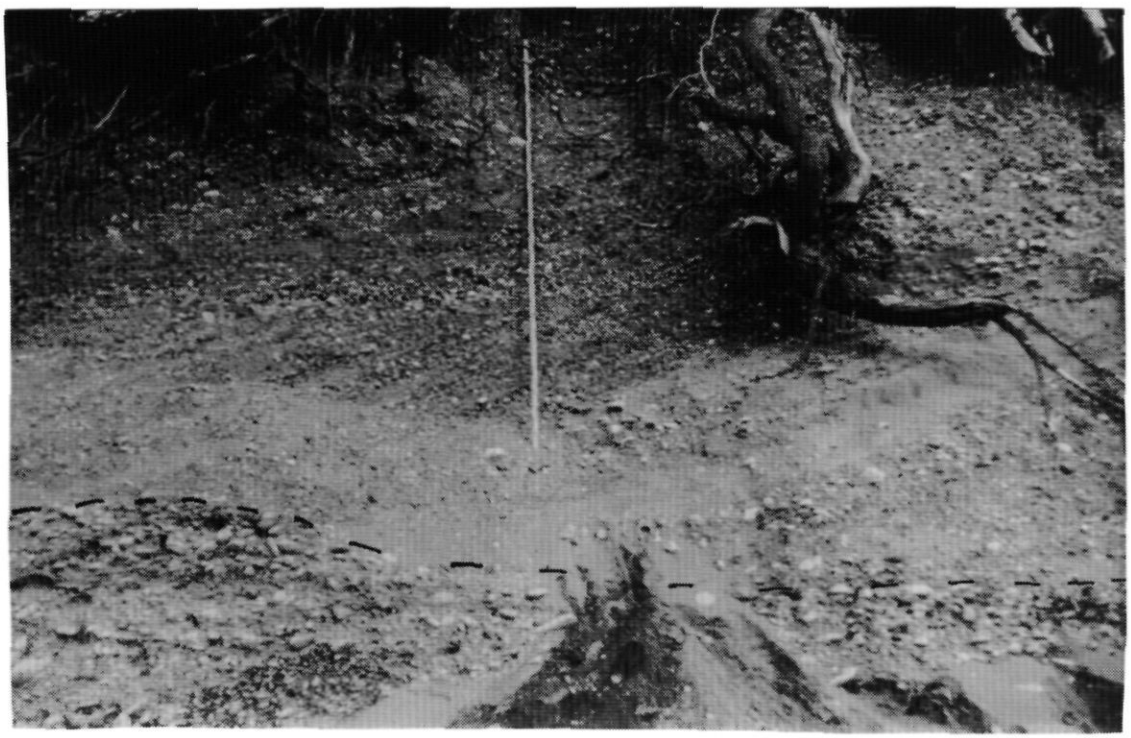


Plate 10. Planar crossbedded gravels, interpreted as transverse bar deposits, in a Holocene terrace on the Quesnel River (Location 48) unconformably overlying cemented gravels. Coarse gold concentrations occur along channel scour surfaces at the base of the younger gravels (dashed line). Measuring rod is 4 metres long.

Fining-up trough crossbedded units are interpreted as channel-fill sequences. Planar crossbedded facies are interpreted as foreset beds developed on transverse bars. Interbedded cross-stratified sands represent associated sand bars and channel bedforms (ripples and dunes). In well studied fluvial placers with characteristics similar to these deposits, gold concentrations are highest on scour surfaces with gravel lags, at the base (lowest surface of degradation) and top (winnowed surface) of clast-supported gravel units, and on bedding surfaces and pebbly beds in sandy facies (Smith and Minter, 1980; Minter,1991; Minter *et al.*, 1993). Lower concentrations of gold in planar crossbedded gravel facies compared to trough crossbedded gravels reflect rapid deposition on bar foresets with less opportunity for reworking of bed materials in the former (Smith and Minter, 1980).

FINE-GRAINED, MATRIX-SUPPORTED DIAMICTON

Deposits of fine-grained matrix-supported diamicton are characterized by ungraded, usually matrix-supported diamicton beds with a fine-grained matrix that includes silts and clays as well as sands (Plate 11). Clasts vary from angular to rounded and are either randomly oriented or have weak preferred a-axis orientations parallel to flow. These deposits locally exhibit crude bedding and may be interbedded with stratified sand and gravel facies (Plate 11). Bed contacts are usually gradational or loaded and commonly conform to the underlying topography, with beds thickening in low areas.

Poor sorting, matrix support, numerous angular clasts, random or weak fabrics and crude bedding are typical of cohesive debris-flow deposits (Lowe, 1979, 1982; Harvey, 1984; Kochel and Johnson, 1984; Wells, 1984; Walton and Palmer, 1988). The geometry of the flows and interbedding with fluvial deposits suggests that they were confined to intermittently active channels. As there is little opportunity for gold to be concentrated during laminar, cohesive debris-flow events, gold within these deposits must have been incorporated into the flows from pre-existing unconsolidated placer concentrates, such as residual, colluvial or alluvial placers. Gold particles vary from angular to rounded, further suggesting derivation from both local (colluvial or residual) sources and fluvially reworked deposits. Minter *et al,* (1988) also found that muddy debris-flow placers are rare, occurring only where debris-flow facies entrained gold from older placers in the substrate. Gold values in debris-flow deposits are generally more uniform and grades are typically lower than in fluvial deposits, reflecting both dilution and mixing of the original placer concentrates by the flows prior to deposition.

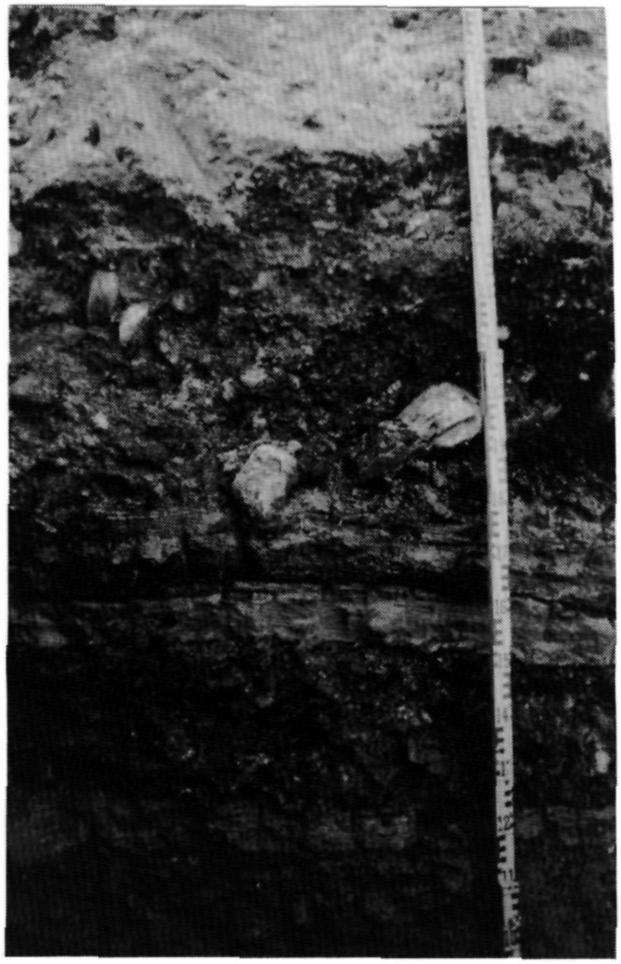


Plate 11. Gold-bearing, massive, matrix-supported diamicton beds interpreted as cohesive debris-flow deposits at the Toop Nugget mine (Location 15). Note the silt interbeds and the variability in clast angularity and orientation in diamicton bds. Gravels overlying the uppermost diamicton beds indicate intermittent fluvial reworking of the debris-flow deposits. (Scale in centimetres.)

CHAPTER 4 PALEOGEOMORPHIC SETTINGS AND DEPOSITIONAL ENVIRONMENTS

INTRODUCTION

The sedimentary characteristics and genesis of auriferous lithofacies typical of fluvial, glacial, glaciofluvial, alluvial fan and colluvial environments are described in this chapter. Most of the deposits investigated in this study originated in fluvial environments and virtually all are paleoplacers. Gravelly, braided stream deposits dominate over other deposit types. Wandering gravel-bed river and meandering stream deposits are rarely recognized. Low sinuosity, single-channel stream deposits are locally common in mountainous areas with steep paleochannel gradients.

INFLUENCE OF DEPOSITIONAL ENVIRONMENT ON GOLD DISTRIBUTION

Patterns of gold distribution and concentration are different in each of these depositional environments. In general, gold in fluvial channels is most concentrated at sites with a high likelihood of sediment reworking, such as areas of parallel flow along straight channel reaches or, more commonly, in areas of convergent flow at channel confluences and along the outsides of channel bends (Mosley and Schumm, 1977; Smith and Minter, 1980; Best and Brayshaw, 1985). Areas of divergent flow such as at the margins of transverse bars and the insides of channel bends, are usually sites of low flow velocities and, if deposition is rapid, little placer concentration will occur.

Coarse placer gold within fluvial deposits appears to occur mainly in lag gravels along channel scour surfaces and possibly also in winnowed bar-top gravels (Smith and Minter, 1980; Minter,1991). Gold concentrations also occur in coarse bar-head gravels where flow velocities are high (Slingerland and Smith, 1986; Day and Fletcher, 1989, 1991; Fletcher and Wolcott, 1991). Deposition of fine gold, carried in suspension, is probably more evenly distributed through finer grained sediments, being influenced more by lateral than vertical facies changes: deposition occurs mainly at sites where stream competence initially decreases such as at chute-channel mouths, along the upstream margin of point bars, in the lee of obstacles like boulders or gravel bars, and, less likely, in proximal overbank deposits. Significant placer accumulations will occur at these sites only if the supply of heavy minerals is replenished and if lighter minerals are continuously removed.

The importance of flow separation processes in the concentration of gold and other heavy minerals was discussed by Best and Brayshaw (1985). At a small scale, flow separation occurs around flow obstacles such as large boulders and in the lee of ripples and bars, and, at a larger scale, at channel confluences and meander bends. Heavy mineral concentrations up to eight times background levels were produced experimentally around spherical flow obstacles in four zones: one on each flank of the obstacle's wake in positions of highly variable flow velocity and turbulence, one upstream from the obstacle attributed to the formation of a horseshoe vortex, and one at the site of flow reattachment downstream of the wake. Heavy mineral dilution occurred in a horseshoe-shaped arc immediately upstream from the obstacle and in the centre of the wake zone. The effects of flow separation were observed for a distance of approximately five obstacle-diameters downstream (Best and Brayshaw, 1985).

Gold distribution in braided stream deposits is commonly sporadic due to random erosion and temporary redeposition of bars and channel sediments (Smith and Minter, 1980). In contrast, high gold concentrations in single-channel streams, particularly those with steep gradients, occur in narrower, more well defined and more continuous zones (Levson and Morison, in press). These pay streaks are essentially paleochannel thalwegs characterized by the presence of coarse lag-gravel deposits with basal erosional unconformities due to channel incision. Enhanced heavy mineral concentrations in incised channels are probably due to the higher energy conditions required to excavate them (Teeuw *et al.*, 1991). Gold within these incised, narrow, paleochannels is commonly angular and coarse, with nuggets up to a few centimetres in diameter not uncommon (Plate 12). In comparison, gold particles deposited in other fluvial environments such as braided streams, tend to be more rounded, flattened and smaller (Plate 13).

In alluvial fan placers, gold distribution is more widely dispersed and concentrations are generally lower than in stream environments, due to the greater abundance of debris-flow deposits and the relative lack of persistent channelling. Gold in alluvial fan placers occurs in a wide range of sizes; nuggets tend to be more angular than in fluvial placers and strongly flattened or flaky gold is uncommon. Glaciofluvial placer deposits are characterized by even lower gold concentrations, due to comparatively rapid deposition and frequently shifting channels in proximal braided stream environments. However, unlike rare till placers, which contain irregularly distributed gold concentrations that lack basal enrichments over bedrock, glaciofluvial deposits have gold distribution patterns similar to fluvial deposits (Herail *et al.*, 1989a).

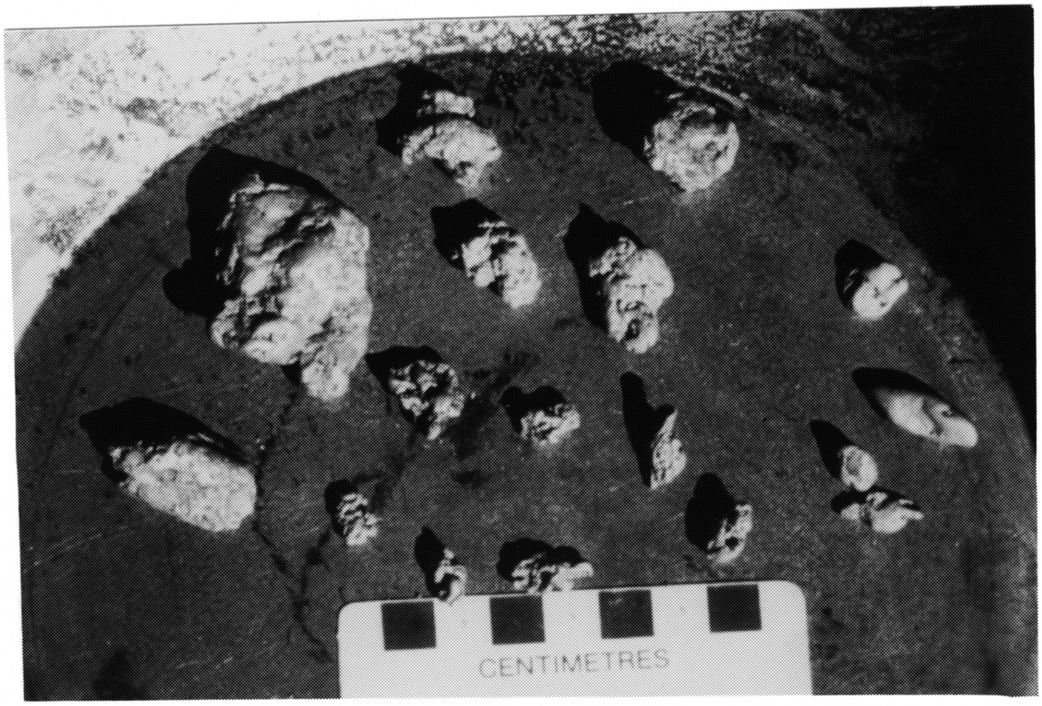


Plate 12. Coarse, gold nuggets mined from paleogulch deposits at Stevens Gulch (Location 10).

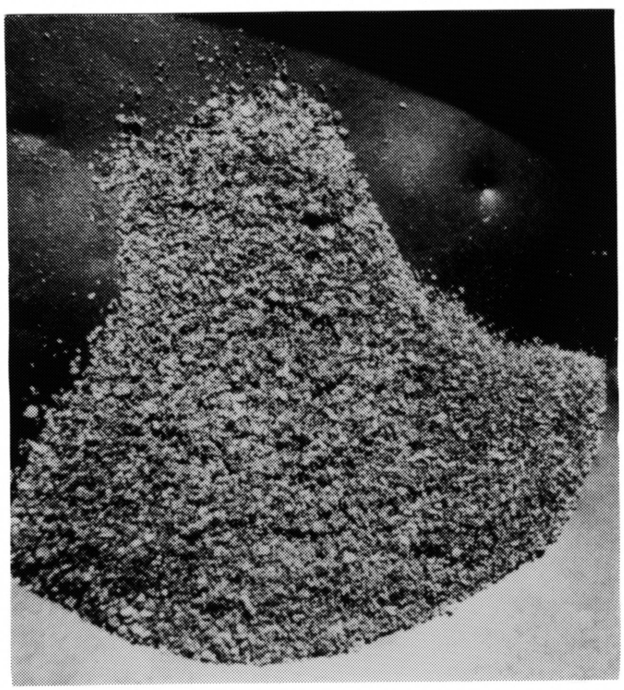


Plate 13. Small, flattened gold particles with rounded edges typical of gold found in braided stream environments.

GEOLOGIC SETTINGS OF CARIBOO PLACERS

In the most general terms, placer deposits in the Cariboo occur in two distinct geologic settings: buried channel and fan deposits usually of Tertiary or Pleistocene (pre-Late Wisconsinan) age and surficial fluvial, colluvial, glacial and glaciofluvial placers generally of Late Wisconsinan or Holocene age. These two categories of deposits are distinguished not only because of sedimentologic and stratigraphic differences, but also because significantly different exploration and mining strategies are required to locate and develop them.

On the basis of lithofacies interpretations and paleoenvironmental reconstructions, buried placer deposits have been subdivided into paleochannel and paleoalluvial fan/fan-delta deposits. Of these, paleochannel deposits are the most common and have been further classified into four types with distinctive sedimentary characteristics and geomorphic settings (Figure 18). Criteria used to distinguish these different settings are provided in more detail below. Paleoalluvial fan and fan-delta sediments are discussed separately from paleochannel deposits as they occur in relatively unconfined depositional environments and have a distinctive sedimentary nature. They are typically dominated by massive or graded, poorly sorted, pebble to boulder gravels with interbedded diamicton and sandy deposits. In contrast, gravels in most fluvial paleochannel settings are typically imbricated, pebble to cobble sized and locally contain sandy interbeds and lenses. Scoured lower contacts in gravel beds are often overlain by concentrations of coarse clasts and are good placer targets. Basal gravels over bedrock typically contain the highest gold concentrations.

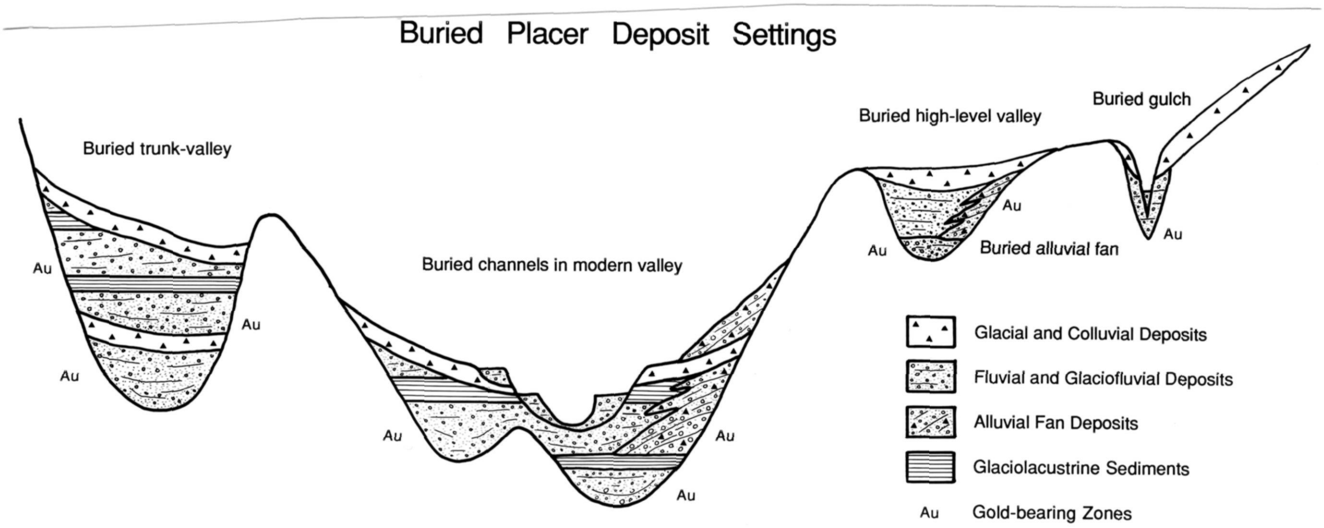


Figure 18. Schematic cross-section of buried placer deposit settings. Typical stratigraphic and geomorphic settings of each type of deposit are illustrated. Large, buried-valley deposits occur both as isolated trunk-valley remnants and within modern valleys. Smaller, but often higher grade, deposits occur in narrow, high-gradient, paleogulch channels. Deposits of intermediate size occur as elevated, buried-channel remnants. Paleoalluvial fan deposits may occur within any buried-valley setting. Gold-bearing strata occur mainly in gravels overlying bedrock and, to a lesser extent, over till or glaciolacustrine deposits.

Overlying bedded gravel sequences generally contain less gold and reflect bar sedimentation during aggradational phases.

Surficial placers include Late Wisconsinan till and glaciofluvial outwash deposits and Holocene high and low-terrace deposits, colluvial placers and alluvial fan deposits (Figures 2 to 8). Economic quantities of gold contained within till and glaciofluvial deposits are uncommon. Due to low grades, high clay contents and/or over consolidation, these placer deposits can only be mined where they occur at or near the surface (*i.e.* where overburden removal costs are minimal) and consequently, exploitation of buried glacial or glaciofluvial deposits predating the Late Wisconsinan has not been recorded.

Placer operations mining postglacial terrace deposits are common in the Cariboo. High-level terraces typically support large-volume, low-grade open-pit placer mines exploiting gravels deposited in aggradational braided streams shortly after deglaciation. Gold is distributed throughout the deposits, mainly at the base of multiple channel-fill sequences. Low-terrace placers generally have been largely depleted by early mining except on downstream reaches where mainly finer grained gold is recovered by open-pit, dredge or floating shovel methods.

Differences in the sedimentologic, geomorphic and stratigraphic characteristics of these placers have direct effects on mining and exploration activities. The classification of placer deposits developed by Levson and Giles (1991) was constructed, in part, to reflect these effects. This classification is used here with some modifications.

BURIED PALEOCHANNEL SETTINGS

Four different types of buried-channel settings (Figure 18), distinguishable mainly by paleostream gradient, present topographic position and deposit size, have been recognized in the Cariboo and in other glaciated parts of the Canadian Cordillera. They are:

- high-gradient (generally more than 0.05 and commonly more than 0.1), narrow valley settings referred to as paleogulches (Figures 2 to 4; Locations 5 to 13)
- abandoned, high-level valleys, containing deposits on the order of tens of metres thick and wide (Figures 4 and 7; Location 23), with intermediate channel gradients (typically 0.01 to 0.1)
- broad, abandoned trunk valleys containing deposits on the order of 100 metres thick, a few hundred metres wide and more than 1 kilometre long (Figures 2 to 4; Locations 14 to 22) with relatively low channel gradients (generally less than 0.02 in mountainous reaches and less than 0.001 in plateau areas)
- channels buried in modern alluvial valleys (Figures 2 to 4; Locations 24 to 31) with stream gradients similar to the modern channels.

The first two settings are dominated by low sinuosity single-channel, autochthonous placer deposits whereas the latter two are characterized by autochthonous and allochthonous placers deposited in braided streams and, to a lesser extent, wandering gravel-bed river environments. The latter, defined by Neill (1973) and Church (1983), are irregularly sinuous, locally braided rivers with intermittently occupied side channels. In contrast, gravelly braided stream environments are characterized by multiple, low sinuosity, unstable channels with high bedloads (Rust and Koster, 1984). In general, both braided stream and wandering gravel-bed river deposits are characterized by massive or crudely stratified, poorly to well imbricated, pebble to cobble gravels, locally with interbedded sands and silts.

Paleogulch placers are distinct from other paleochannel deposits because they occur in comparatively steep, narrow, buried channels and have unique sedimentary characteristics such as high boulder contents. Their deposits typically are thin, crudely stratified, poorly sorted and locally derived. Clasts are commonly angular and up to a few metres in diameter. Pay zones occur on or close to the bedrock surface in the thalweg of the gulch stream-bed.

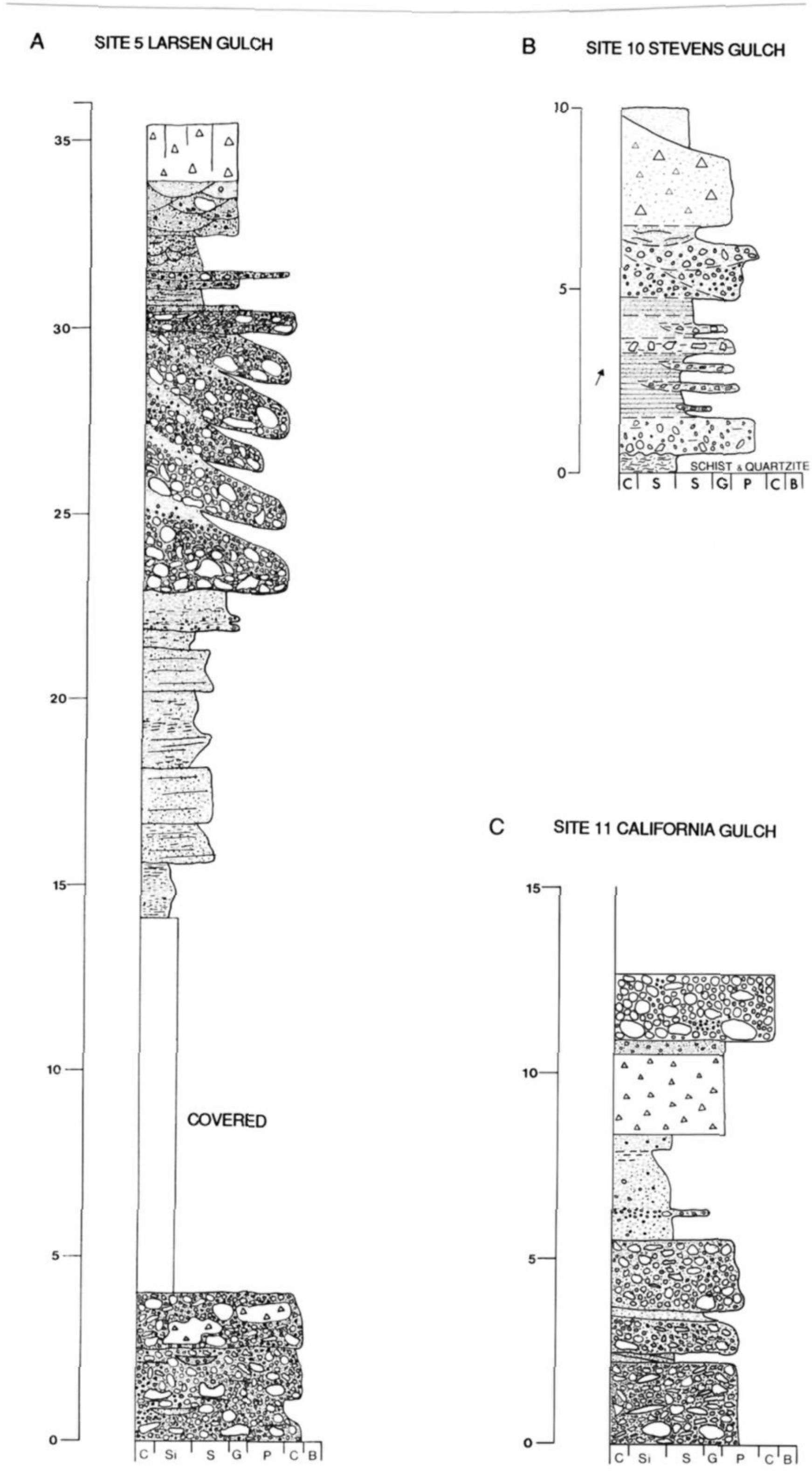


Figure 19. Stratigraphic sections representative of pre-Late Wisconsinan paleogulch placer deposits in the Cariboo region. A) Gold-bearing debris-flow deposits below a thick glaciofluvial delta complex and Late Wisconsinan till at Larsen Gulch (Location 5). B) Gold-bearing, poorly sorted gravels overlain by colluvial diamicton, silt, sand and gravel at Stevens Gulch (Location 10). C) Basal auriferous gravels overlain by barren glaciofluvial and glacial deposits at California Gulch (Location 11). (*See* Figure 14 for legend. Horizontal scale indicates mean grain size: C-clay, S-sand, Si-silt, G-granule, P-pebble, C-cobble, B-boulder.

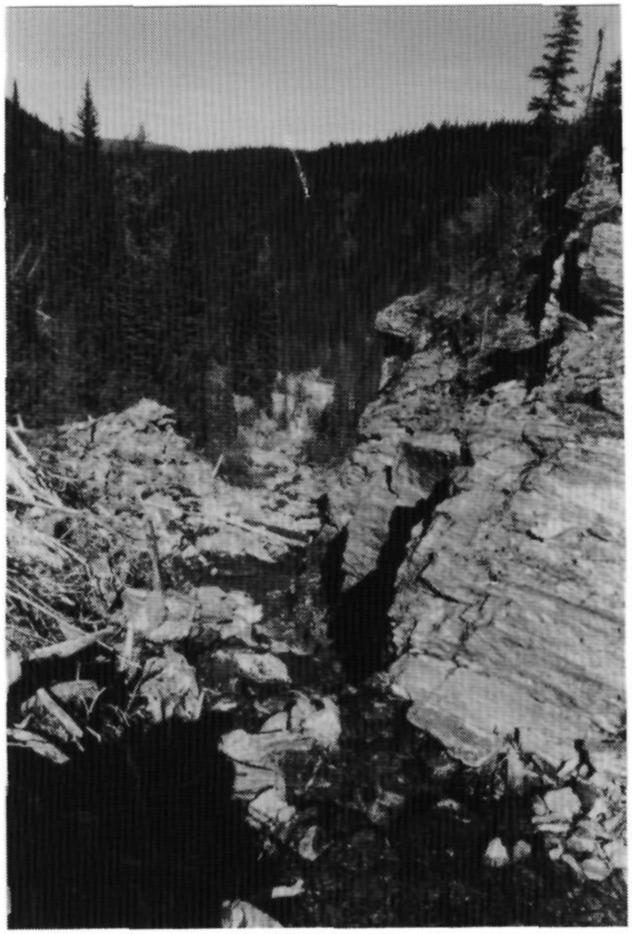


Plate 14. Modern Beggs Gulch channel (Location 9) largely mined out in the 1800s. Note steep gradient, narrow bedrock valley, cobble to boulder gravel bed and bedrock-floored reaches.

Compared to paleogulch placer deposits, other paleochannel placers consist of relatively well-sorted, well-stratified and well-rounded gravels. They occur in broader, lower gradient valleys and are potentially of large volume. Abandoned trunk valleys are usually bedrock walled and filled with stratigraphically complex sequences of gravel, sand, silt, clay and diamicton. They are similar in size to modern trunk valleys but are entirely cut off from active river channels. Abandoned high-level valleys occur at elevations substantially higher than modern streams and may represent channel remnants from periods of relatively high base-level prior to more recent valley incision. They are similar in size to the valleys of modern low order streams that are tributary to main or trunk-valley rivers. Buried channels in modern valleys occur both below recent alluvium and in buried channels adjacent to modern creeks (Figure 18).

SINGLE, LOW SINUOSITY, BEDROCK FLOORED, PALEOCHANNEL DEPOSITS

Placer deposits of this type occur mainly in dissected, high-relief areas in the Quesnel Highlands. Paleochannels in these areas generally have steeper gradients than streams further west in the Fraser Plateau and Basin. The paleochannels tend to be relatively straight, narrow, single and at least partly bedrock floored. They are similar to modern first or second order stream channels in the region. Placer deposits within the paleochannels are dominated by coarse gravels with few fines due to the relatively high energy of the depositional system. The streams were largely erosional with deposition occurring mainly where the channels widened or gradients decreased. Erosion of the channel floor and input of sediment from the valley walls in these confined streams results in an abundance of locally derived materials. These fluvial systems behave much like natural sluices, concentrating gold both in basal, coarse gravel facies and in riffles created by bedrock fractures, joints, beds or foliation planes. Some gold may also be reconcentrated from these zones into overlying gravel units deposited during the initial phases of channel aggradation. Subsequent channel abandonment and burial usually occur, often as a result of changes in base level, discharge or sediment load associated with glaciation.

PALEOGULCH (HIGH-GRADIENT) CHANNEL DEPOSITS

Gulches are small, narrow valleys with steep sides that commonly occur as first or second order tributaries to larger, higher order, trunk valleys in areas of high relief (Plate 14). They typically have single, steep gradient (>0.05), low sinuosity channels. Cobble to boulder gravel beds and bedrock floored reaches are common. They carry large volumes of water and sediment during episodic floods generated by unusual snow melt or heavy rainfall. These floods may recur at intervals of tens to hundreds of years. Increased stream discharge and velocity result in large increases in the amount and size of material that is moved. High stream discharge, capacity and competence are ideal for mobilizing and reconcentrating coarse placer gold and consequently gulch placers in the Cariboo have proven to be most productive. Similar deposits from the Tertiary Cangalli Formation in Bolivia, described as fluvio-torrential deposits, contain 20 to 110 grams of gold per cubic metre (Herail *et al.*, 1989b). Paleogulch placers are mined at a number of areas in the Cariboo (Figures 2 to 4, Locations 5 to 13, 21, 42).

Paleogulch channel deposits typically consist of massive or crudely stratified, poorly sorted, weakly imbricated, cobble to boulder-sized gravels (Figure 19). Relatively high angularity and local derivation of clasts suggest a local provenance. Steep channel gradients, large clast sizes and dominantly local lithologies are typical of low order streams in the upper parts of mountainous drainage basins. These streams have limited drainage areas and their deposits are mainly autochthonous, occurring near their primary ore source (Kartashov, 1971). Gold within these deposits is commonly angular and coarse (Plate 12) further suggesting a local source. Of the nine paleogulch placer deposits described in this study, eight occur at sites within the Barkerville Terrane in areas underlain by bedrock of the Snowshoe Group, mainly the Downey and Harveys Ridge successions. This relationship between these well known hostrocks (Struik, 1988) and placer deposits of this type further reflects the autochthonous nature of paleogulch placers.

The deposits exposed at several mines along tributary streams to Antler Creek are typical of paleogulch gravels in the Cariboo. For example, placer deposits at California

Gulch (Location 11, Figures 4 and 7) consist of massive, poorly sorted, clast-supported, pebble to cobble gravels with some boulders and a fine sand and silt matrix (Unit 1, Section 8911, Appendix B). Tabular clasts generally lie flat ,giving the appearance of crude horizontal bedding. They are interpreted as paleogulch channel gravels, predating the last glaciation, deposited by flows with high discharge and sediment loads. The gravels are buried by over 10 metres of nonauriferous sand and gravel and matrix-supported diamicton (Figure 19C).

Paleogulch placer deposits often thin rapidly toward the channel margins where they are interbedded with colluvial sediments. Mining at Stevens Gulch (Location 10; Figures 4 and 7) has exposed approximately 1 metre of poorly sorted, medium to large-pebble gold-bearing gravel, overlain by several metres of diamicton, sand and minor gravel (Figure 19B). Bedrock is exposed at the base of the section and the upper surface slopes towards the valley centre. The gold-bearing gravel (Unit 2, Section 9010, Appendix B) thins toward the valley side where bedrock rises. It contains rounded clasts and coarse nuggets, commonly 8 to 16 grams (Plate 12), and is interpreted as a paleogulch fluvial placer. It was presumably missed by previous mining activities because of its channel-margin position. The presence of some locally derived, angular rocks suggests colluvial reworking of the original fluvial deposits. Small debris flows along the margins of the paleogulch channel probably remobilized auriferous alluvium and incorporated local materials. Sand and interbedded diamicton (Unit 3, Section 9010, Appendix B) overlying the main auriferous sediments contain some gold and are presumably of a similar origin. The sands are horizontally laminated and were probably deposited by slow moving water within the channel. They decrease in abundance toward the valley side where diamicton dominates. A debris-flow origin for the diamicton beds is suspected because of the massive structure, chaotic fabric, dominance of angular local clasts and poor sorting. Interbedded diamicton, poorly sorted gravel and small sand lenses in the upper part of the section contain little or no gold and are interpreted as colluvial and alluvial deposits.

Highly variable flow conditions are typical of gulch channels and the resultant deposits are characterized by sharp lateral and vertical variations in the grain size and sorting. In addition, colluvial sediments are commonly introduced into the channels from the valley walls and, in Pleistocene deposits, glaciofluvial gravels may also be associated with the gulch deposits. Distinguishing these colluvial and glaciofluvial deposits from the typically more auriferous paleochannel deposits can be problematic. For example, a recent mining operation targeting a possible buried gulch channel at Beggs Gulch (Location 9; Figures 4 and 7) has exposed well-sorted sand beds that dip up to 50° to the northwest (300°) and grade vertically into a sandy boulder gravel (Section 8909, Appendix B). The section is overlain by about 3 metres of colluvial debris including some very large angular boulders (up to several metres in diameter) derived from the adjacent slope. The origin of the recently mined valley-fill sequence is enigmatic. The deposits may be related to an old gulch paralleling the modern Beggs Gulch channel or they may be glaciofluvial or entirely colluvial in origin. The high angle of bedding and amount of deformation of strata indicate collapse, possibly associated with melting of glacial ice, or due to slumping along the margins of a paleogulch. Boulders are both locally and distally derived giving little clue as to a glaciofluvial, colluvial or fluvial origin.

Paleogulch placers, like other buried-channel deposits, are typically covered by thick deposits of till, glaciofluvial deposits and glaciolacustrine sediments. At California Gulch, for example, the overburden includes a thick sequence of sands and gravels (Figure 19C) interpreted as glaciofluvial delta or kame delta sediments that were deposited when a glacier, occupying the Antler Creek valley, dammed the local drainage. Prodelta bottomset beds, foreset beds and topset beds are represented, respectively by parallel laminated sands, steeply dipping gravels and sands, and normally graded fine sand and silt beds (Units 2 to 4, Section 8911, Appendix B). The inclination of foreset beds indicates a southeasterly source for the delta deposits. Ripple bedding and some channel structures occur in the topset sequence and intrastratal faults indicate syndepositional deformation. Massive, silty, matrix-supported diamicton sharply overlying the deltaic sequence (Figure 19C) is interpreted as till deposited by glaciers over-riding the area. Horizontal parting surfaces within the diamicton, that dip parallel to the slope, indicate possible reworking of the till by colluvial processes subsequent to its deposition. Massive to crudely stratified sands and gravels (Figure 19C; Units 6 and 7, Section 8911, Appendix B) capping the sequence were probably deposited by ice-marginal streams during deglaciation, forming a small kame terrace.

Some paleogulch placers were mined hydraulically in the past and modern workings commonly are either above the upper elevation reached by the hydraulic operations or along the valley sides where remnants of buried pay gravel are preserved. A small mine at Larsen Gulch (Figures 3 and 10, Location 5) is an example of an operation exploiting remnant paleogulch gravel left above the upper limit of former hydraulic mining. The gold-bearing deposits are poorly to moderately well sorted, pebble to large-cobble gravels with some iron and manganese-stained openwork beds. Stratification and imbrication in these deposits suggests that they originated as coarse, gravelly debris flows with intermittent stream flow, typical of a gulch or alluvial fan setting. The upper sequence of deposits at this site (Figure 19A) is interpreted as glaciofluvial deltaic sediments. Steep foreset beds that dip up Larsen Gulch dominate the sequence and indicate that the gulch was dammed by a trunk valley glacier prior to the last advance of ice over the area. The deposits coarsen upwards, probably indicating the advance of ice into the region. Drainage in the valley was probably blocked by a glacier flowing north along the Beaverpass valley. This is reflected in the deposition of glaciolacustrine silts and fine sands (bottomset beds) at the base of the sequence (Unit 1, Section 8905B, Appendix B). Meltwater from ice in the Beaverpass valley deposited the foresetted gravels (Unit 2) in a proximal, glaciofluvial delta that prograded over the glacial lake sediments in the Rucheon valley. The foreset beds contain clasts up to boulder size, indicating the proximity of ice, and they are capped by a layer of coarse topset gravel (Unit 3). The uppermost sand and gravel strata (Unit 4) are interpreted as braided stream channel and bar sediments deposited on top of the deltaic sequence. The entire sequence is capped by a diamicton (Unit 5) inferred to be a till deposited by overriding ice.

Small exposures of paleogulch deposits at the Black Creek mine (Location 13, Figures 2 and 6) reveal massive, fining-upward gravel sequences (Unit 4, Section 9013B, Appendix B) interpreted as channel-fill deposits. These gravels are directly overlain by 10 metres of parallel-laminated fine sands, silts and clays (Units 5 and 6) interpreted as bottomset and toeset glaciolacustrine sediments deposited in an ice-marginal lake, presumably dammed by main-valley ice. The sediments in Unit 5 change in texture from medium sands at the base to sandy clays at the top, probably reflecting higher energy conditions during the initial formation of the lake and more quiescent conditions subsequently. The sediments exhibit structures typical of shallow subaqueous deposits including both normal graded laminae and climbing ripple bedding. Beds dip 20 to 30° away from the valley centre in a direction opposite to the present drainage. Overlying massive to normally graded, steeply dipping gravel beds (Units 7 and 8) are interpreted as foreset beds deposited in a prograding glaciofluvial delta. Gradual upward coarsening of the underlying toeset deposits (Unit 6), from silts and fine sands at the base to medium and coarse sands at the top, also reflects delta progradation. Overlying cobble to pebble gravel beds fining upward into sands and silts (Units 9 and 10) are interpreted as topset distributary channel-fill sequences. Beds dip gently to the northwest. These deposits are erosionally overlain by planar crossbedded gravels with trough-shaped lower contacts interpreted as linguoid bar gravels. Some beds (*e.g.*, Unit 11) have opposing dips across horizontal distances of several metres, reflecting foreset deposition along opposite margins of single bars. Erosional, trough-shaped, lower contacts marked by coarse gravel lags presumably reflect scouring downstream of the bars and in channels. The uppermost deposit at this site is a massive diamicton containing numerous cobbles and boulders and striated clasts. It is interpreted as a Late Wisconsinan till.

Most paleogulch placer deposits in the Cariboo were totally buried during the last glaciation and the thick glacial overburden prohibits open-pit mining. Locating, evaluating and mining these buried, but potentially rich, placers can be both difficult and costly and usually requires detailed geologic information. However, at some active paleogulch placer mines the glacial overburden has been partially excavated by Holocene stream erosion. In addition, in a few areas, Holocene streams that reoccupied preglacial and interglacial channels, eroded through the overburden and locally reconcentrated the ancient placers. Examples of paleogulch deposits that have been partially exposed and reworked by modern channels include Lynn and Oliver gulches on Spanish Mountain (Figures 2 and 12, Location 21). Mined deposits may include both preexisting sediments into which the modern gulches have incised and colluvial deposits along the valley sides. In places, poorly sorted large-boulder gravel occurs in the gulches and hampers deeper mining. Most Holocene gulch placers were mined out in the 1800s due to the relative ease of exploration and mining, compared to most paleogulch placers.

In addition to large buried-gulch placers, small abandoned channels adjacent to modern gulches are also potential placer targets. A small paleochannel along the southeastern margin of Beggs Gulch, for example, has been successively mined for coarse gold. Bedrock exposed at the base of the channel is well water-worn and a small paleo-waterfall and plunge pool are apparent. The channel gravels are coarse, some clasts being up to a few metres in diameter.

ABANDONED HIGH-LEVEL PALEOCHANNEL DEPOSITS

Placer deposits occurring in buried, high-level valleys, are restricted mainly to mountainous areas in the eastern part of the study region. These deposits occur as paleochannel remnants, 20 to 100 metres above modern streams. The paleochannels are generally single and straight to slightly sinuous with gentler slopes than paleogulch channels (typically much less than 0.1). They are usually oriented more or less parallel to adjacent modern stream valleys and have similar gradients, suggesting that they were formed by these streams when they flowed at a higher elevations prior to more recent down-cutting. They tend to be similar in size to nearby tributary stream channels and typically contain deposits on the order of tens of metres wide and several to tens of metres thick. Gold within these deposits is coarse and considered to be mainly autochthonous. The Butcher bench on Lightning Creek above Stanley (Figure 7) is a well known example of this type of placer deposit. Johnston and Uglow (1926) described the bench as a gently sloping bedrock channel, 20 to 25 metres above Lightning Creek, cut when the creek flowed at a much higher level than at present. The bench reportedly produced over 185 000 grams of gold from an area of only a few square metres, as well as the largest known Cariboo nugget weighing 1121.5 grams (Johnston and Uglow, 1926). Other high-level buried paleochannel deposits are also known in this area, such as the Dunbar benches, which were mined hydraulically by several different companies (Plate 15). The benches occur at a number of different levels, one of which may be an upstream continuation of Butcher bench.

An excellent example of a recently worked, high-level buried-valley placer deposit is provided by the Streicek mine (Figures 4 and 7, Location 23, Plate 16). The gold-bearing gravelly sequence at this site can be divided into two parts. The lower part (Units 1 to 4, Section 9023, Appendix B) consists of partially openwork, cobble to boulder gravels interpreted as high-energy, fluvial gravels deposited in a narrow bedrock-confined channel (Figure 20). A well-developed pebble imbrication, indicating a general northerly (downslope) paleoflow (Figure 21), is consistent with a fluvial origin for the gravels. Sorting and stratification increase with depth as does the abundance of openwork beds reflecting the increased influence of fluvial action. The gravels have a large component of well-rounded, white quartzitic rocks as well as abundant, angular phyllites. Gravel units,

Plate 15. Hydraulically mined high-level, buried-valley placer deposit, parallel to Lightning Creek above Stanley known as the Dunbar bench.

Plate 16. Mining buried paleochannel gravel on a high bench above Devils Lake Creek at the Streicek mine (Location 23).

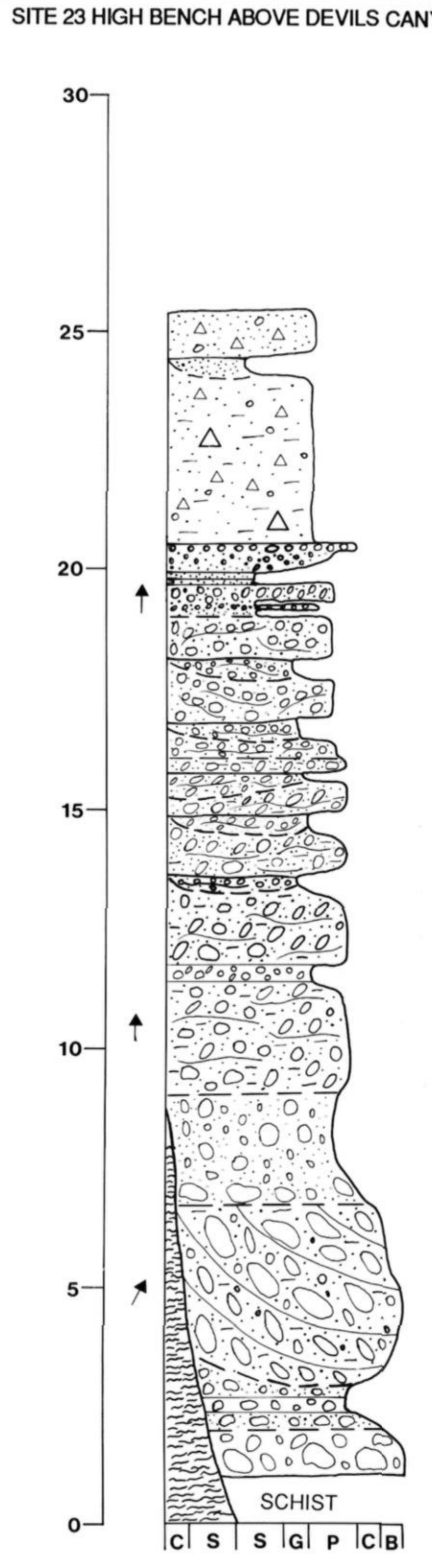


Figure 20. Auriferous, trough crossbedded, paleochannel gravels overlain by horizontally bedded glaciofluvial gravels and massive, glacial diamicton on a high bench above Devils Lake Creek at the Streicek mine (Location 23). *See* Figure 14 for legend. Horizontal scale indicates mean grain size: C-clay, S-sand, Si-silt, G-granule, P-pebble, C-cobble, B-boulder.

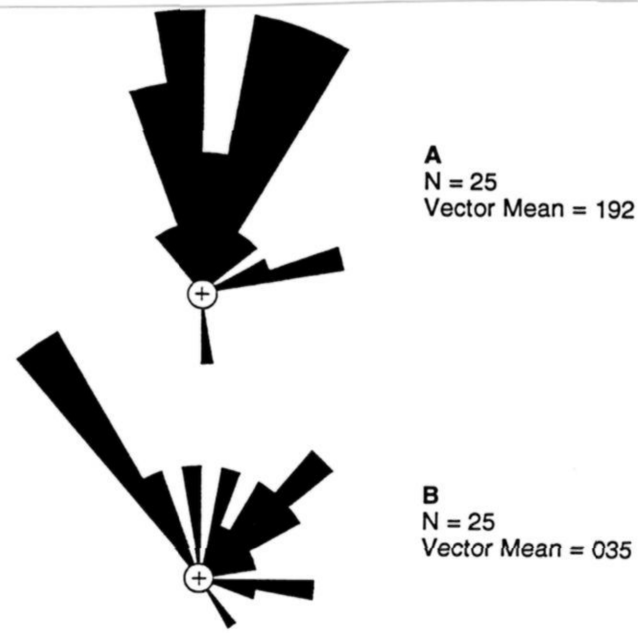


Figure 21. Rose diagrams showing paleoflow directions in upper (fabric A) and lower (fabric B) gravel units at the Streicek mine (Location 23), as indicated by pebble imbrication data.

overlying bedrock along the channel wall, are poorly sorted and have been reworked by gravity. They are dominated by locally derived angular clasts that dip steeply (up to 45°) into the channel centre due to downslope colluvial processes during channel infilling.

The upper part of the buried gravel sequence at the Streicek mine (Figure 20) consists mainly of poorly sorted, pebble gravels and sands with crude horizontal stratification, probably deposited in a less confined, glaciofluvial, braided stream (see Units 4 to 8 at Section 9023 and Units 1 and 2 at Section 8923, Appendix B). These deposits are mainly medium to large-pebble gravels with some thin, openwork, small-pebble lenses. They fine upward and become progressively better sorted and stratified, possibly reflecting a shift from rapid channel aggradation to sedimentation in more stable channels. An increase in gold content in the gravels with depth is probably also a reflection of depositional environment. The highest gold production comes from the basal channel gravels where high-energy stream erosion during relatively long periods of time favoured the selective accumulation of gold. In contrast, the upper part of the gravel sequence appears to have been deposited during channel aggradation, effectively inhibiting the concentration of gold. The gold-bearing gravels are unconformably overlain by a dominantly massive, matrix-supported diamicton sequence interpreted as Late Wisconsinan till and glacially derived debris-flow deposits (*see* Units 9 and 10, Section 9023, Appendix B).

BURIED, BRAIDED STREAM AND WANDERING, GRAVEL-BED RIVER DEPOSITS

Most large buried paleochannel deposits in the Cariboo are interpreted as braided stream or wandering gravel-bed river deposits. Gravelly braided stream deposits are typically dominated by channelling, fining-upward sequences of clast-supported, imbricated gravels with crude horizontal stratification formed by aggradation of mainly longitudinal bar deposits in multiple, low sinuosity, unstable channels (Miall, 1977; Rust and Koster, 1984). Many large modern streams in the study area can be considered to be of the 'wandering gravel-bed type', exhibiting sinuous to straight, gravel-bed channels, commonly with islands and seasonal or perennial side channels (Church, 1983; Desloges and Church, 1987). Wandering gravel-bed river deposits are generally characterized by several metres of channel gravels overlain by up to a few metres of sands and overbank silts, but their probability of preservation is lower than braided stream deposits (Desloges and Church, 1987). Buried, braided stream and wandering gravel-bed deposits occur in two different geomorphic settings in the Cariboo: abandoned trunk-valley settings, isolated from present valleys, and in paleochannels within modern valleys, either buried directly below modern alluvium or in buried channels that occur adjacent to, and often are intersected by, modern creeks.

ABANDONED, GRAVEL-BED PALEOTRUNK-VALLEY DEPOSITS

Abandoned trunk-valley placer deposits typically consist of gravel-dominated paleochannel sequences that occur in broad bedrock valleys on the order of hundreds of metres wide and deep, similar in size to modern trunk (high order) valleys. They generally are not occupied by modern streams and typically are graded to higher base levels than modern streams in adjacent valleys and, therefore, usually can be considered to be 'dry' valleys. Paleochannel gradients are relatively low, ranging from about 0.015 to less than 0.001, similar to modern trunk-stream gradients. Most of these large paleochannel placers are dominated by crudely bedded, multiple, gravelly channel-fill sequences, typical of braided stream environments. At a few locations, the gravels exhibit characteristics suggestive of wandering gravel-bed rivers such as thick channel-gravel deposits with minor overbank silts and sands. Gold-bearing gravels in these large paleochannels are usually massive to crudely stratified, clast supported and imbricated. The gold is generally allochthonous (or distally derived) although coarse autochthonous gold also occurs locally where the paleochannels directly eroded source rocks. The auriferous deposits are typically buried by glacial, glaciofluvial and glaciolacustrine sediments associated with one or more glaciations, invariably including the Late Wisconsinan. These Quaternary fill sequences dominate the geology of the large paleovalley systems and their geologic characteristics are exemplified by the deposits exposed at the sites discussed below.

The valley excavated by hydraulic operations at the Bullion mine (Figures 2, 12 and 22, Location 20) is a well known example of a large abandoned Pleistocene valley. The mine occupies a bedrock-walled valley about 1 kilometre long and over 100 metres deep (Plate 17) that is truncated at the north end by the modern Quesnel River. Figure 22 is a composite stratigraphic column illustrating the sequence

Plate 17. The Bullion hydraulic mine near Likely (Location 20). The excavated valley is about 1 kilometre long and is truncated at the north end by the Quesnel River. The hill on the far side of the mine is mainly bedrock but stratified buried-channel sediments are still exposed on its flanks. Till and glaciofluvial deposits from the Late Wisconsinan and an earlier glacial period, as well as intervening mid-Wisconsinan interstadial deposits, are exposed in the mine wall. More than 3860 kilograms (120 000 ounces) of gold were recovered from this site, mainly from paleochannel gravels overlying bedrock. Water ponded at the base of the channel is at the entrance to an underground sluice tunnel extending to the Quesnel River.

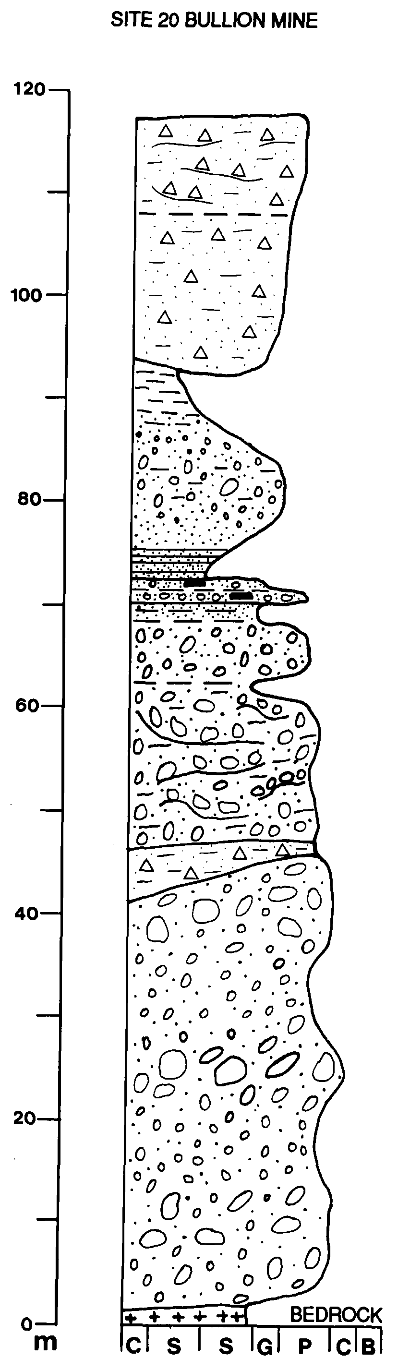


Figure 22. Stratigraphic column of the Bullion mine (Location 20); (modified from Clague *et al.*, 1990). The main gold-bearing zone occurs in gravels of the penultimate glaciation that overlie the basal gravel sequence and they are in turn overlain by mid-Wisconsinan till. *See* Figure 14 for legend. Horizontal scale indicates approximate mean grain size: C-clay, S-sand, Si-silt, G-granule, P-pebble, C-cobble, B-boulder.

of deposits exposed. Sediments from two glacial periods (till and glaciofluvial sand and gravel) and intervening nonglacial deposits are locally preserved in the mine (Clague, 1987b). A few radiocarbon dates were obtained on wood from sand and peat beds between the two tills. Dates

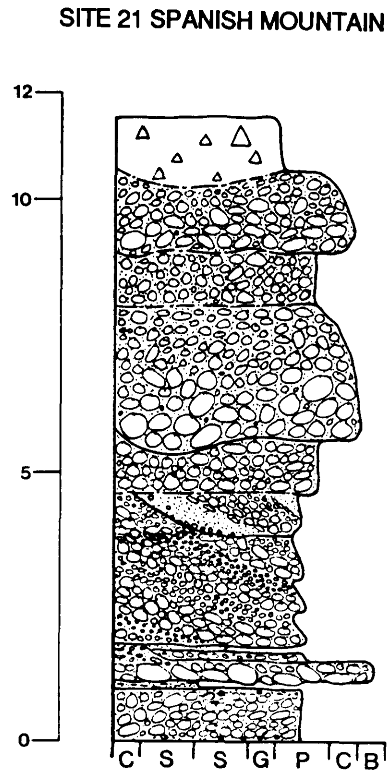


Figure 23. Poorly sorted paleoalluvial fan deposits buried below till at the spanish Mountain McKeown mine (Location 21). *See* Figure 14 for legend. Horizontal scale indicates mean grain size: C-clay, S-sand, Si-silt, G-granule, P-pebble, C-cobble, B-boulder.

from the wood samples range from 36 840±430 years B.P. (TO-392) to 46 300±940 years B.P. (GSC-4411HP), indicating that those beds were deposited during the mid-Wisconsinan interstadial. The mine has produced over 3860 kilograms (120 000 ounces) of gold, mainly from the lowermost gravel on bedrock (Sharpe, 1939). Gold also occurs in stratigraphically higher gravel units, probably overlying clay-rich till or lacustrine deposits that temporally limited erosion. North of Spanish Mountain, along the Cariboo River, Clague (1987b) identified a buried channel similar to the Bullion channel as a possible placer exploration target.

Actively mined deposits at Spanish Mountain (Figures 2, 12 and 23, Location 21) appear to fill the upper part of an elevated erosional channel cut in bedrock. The channel is approximately 1 kilometre long, 300 metres wide and, as indicated by drilling results, at least 74 metres deep. The lower 50 metres is filled with clean pebble and boulder gravel. This gravel has not been mined extensively but there is high potential for it to be gold bearing, particularly at the base. The orientation of the channel is not well defined but appears to be oblique to the regional northwesterly strike of bedrock, topography and glacial ice-flow. This orientation could provide an ideal situation for minimal glacial erosion and may account for the preservation of the placer deposits in the paleochannel. Currently mined deposits, filling the upper part of the channel, are interpreted as alluvial fan sediments (*see* paleoalluvial fan settings).

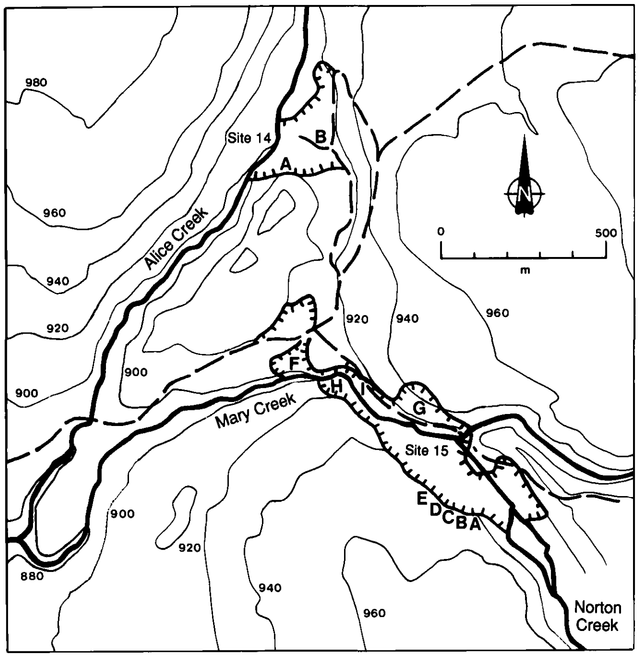


Figure 24. Location map of the Alice Creek (Location 14) and Mary Creek (location 15) placer mines (hachured areas) showing topography and ocations of measured sections.

Preglacial and interglacial stream-channel placers in the Cottonwood River area have been mined in recent years at Mary and Alice creeks (Figures 24, 25 and 26; Locations 14 and 15, Figure 3). The size, number and orientation of the channel(s) is unknown but outcrops of the channel gravel extend over a distance of several hundred metres. A preglacial age of gold-bearing gravel in the region has been corroborated by palynological data (Rouse *et al.*, 1990). At Mary Creek (Location 15), the main gold-bearing gravels (Unit 2, Figure 25; see Section 8915F, Units 1 to 9, Appendix B) are cemented, moderately to well sorted, imbricated, horizontally stratified and interbedded with sands (Plate 18). They are interpreted as preglacial braided stream deposits. They contain rich pay zones with nuggets up to about 100 grams in weight. Glacial erosion of the auriferous deposits may have been minimized as the channel is apparently oriented obliquely to the regional (northerly) direction of ice flow. In addition to the main paleochannel gravels, gold has been recovered from poorly sorted, matrix-supported, stoney clays interpreted as mud-flow deposits (Roed, 1988). Gold-bearing gravels also occur between two diamicton units of glacial origin that overlie the lower cemented gravels (Figure 26B). These gravels may be interglacial or interstadial in age or they may have been deposited in a short-lived proglacial stream during a relatively minor retreat of ice from the area. They are probably correlative with inter-till gravels at Alice Creek (Location 14, Figure 26A) and possibly also with organic-rich interstadial sediments at Mexican Hill, approximately 5 kilometres to the southeast, described by Clague *et al.* (1990). The uppermost sequence of auriferous sediments at this site is

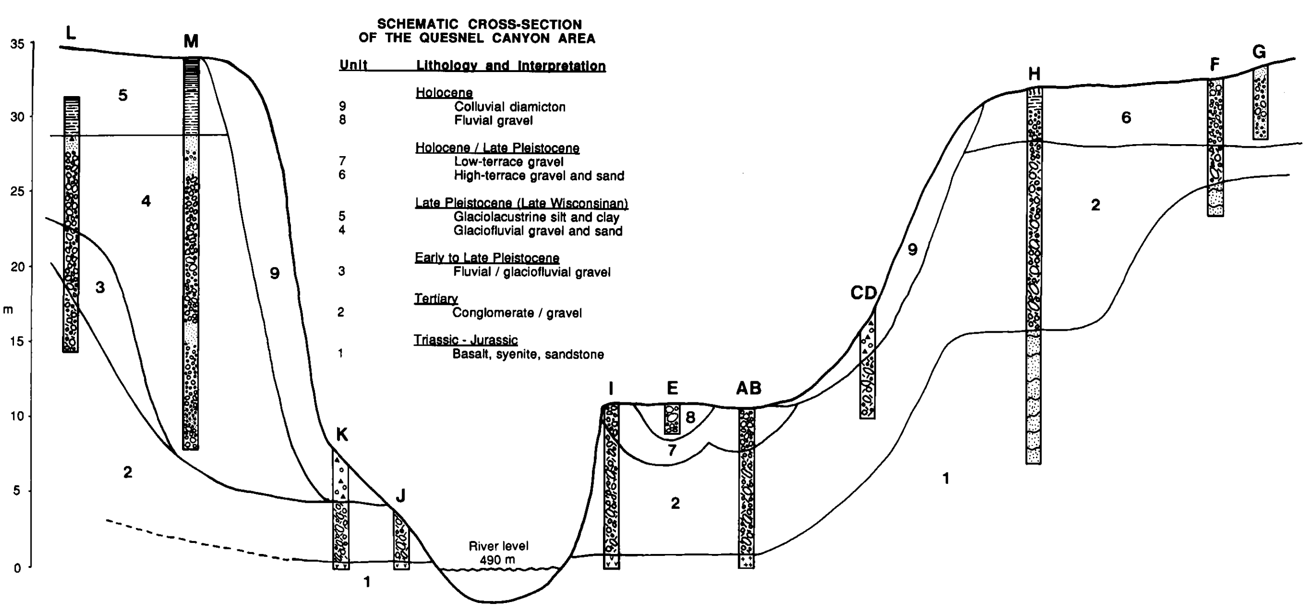


Figure 25. Interpretive geologic cross-section of the Mary Creek area (Location 15). Gold occurs in units of inferred Tertiary (Units 2 and 3), interglacial (Unit 6), late glacial (Unit 8) and Holocene (Unit 9) age. Relative topographic positions of each section are accurately shown; horizontal positions are schematic (capital letters refer to locations of measured sections shown on Figure 24). Stratigraphic correlations are indicated with solid lines.

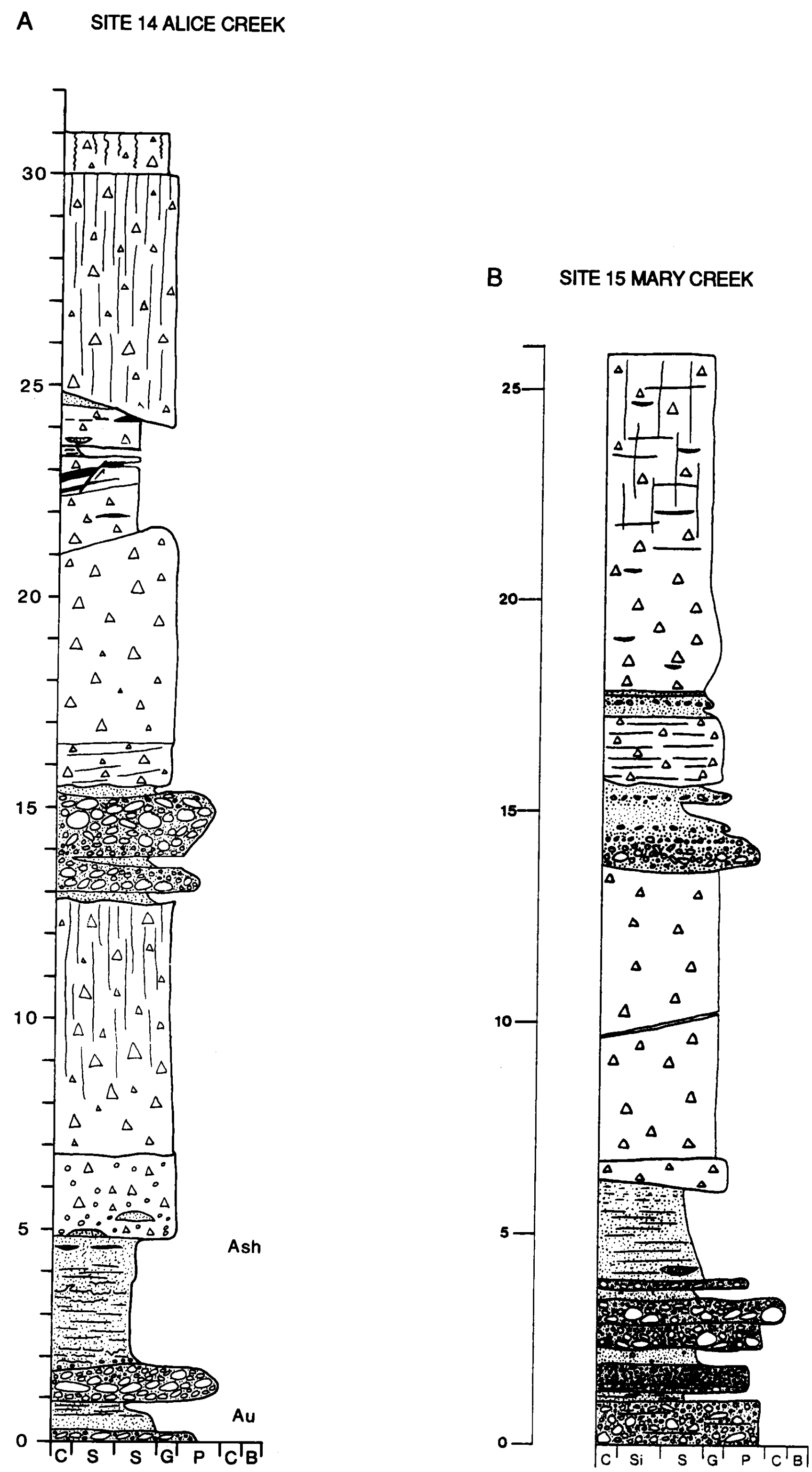


Figure 26. Composite stratigraphic columns of highwall exposures at the A) Alice Creek (Location 14) and B) Toop Nugget mines (Location 15). Basal gold-bearing gravels at both sites are stratigraphically overlain by up to 25 metres of glacial and glaciolacustrine sediments. Intertill sands and gravels are also gold bearing. *See* Figure 14 for legend. Horizontal scale indicates mean grain size: C-clay, S-sand, Si-silt, G-granule, P-pebble, C=-cobble, B-boulder.

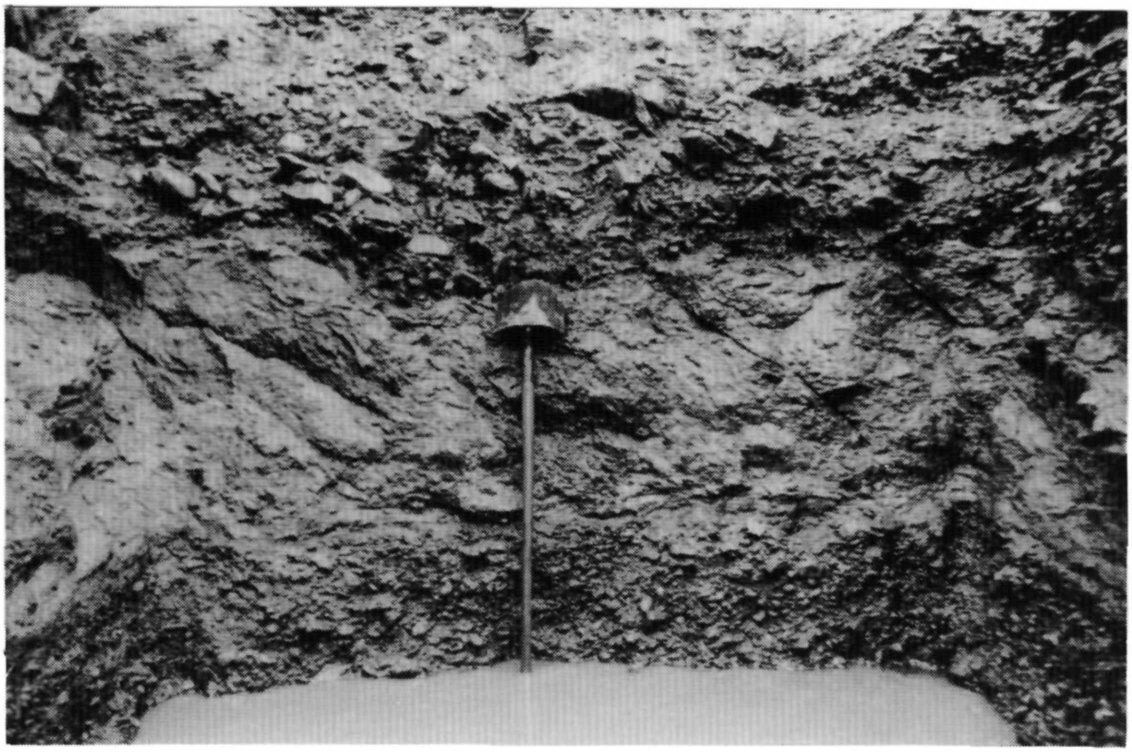


Plate 18. Oxidized, cemented, auriferous, preglacial sand and gravel in an active pit at the Toop Nugget mine (Location 15). Poorly to moderately sorted, clast-supported, weakly imbricated, pebble gravel is interbedded with pebbly sand and silt.

glaciofluvial gravels deposited during deglaciation of the area. Gold in these gravels presumably was incorporated from the older paleochannel gravels.

Pay gravels at Alice Creek (Figures 3 and 11, Location 14) are reportedly 4 to 8 metres thick and consist of massive, poorly sorted, angular to rounded, matrix-filled gravels with patchy oxidation and minor cementation. They were interpreted by site geologists as debris-flow deposits (M. Poschner, personal communication, 1989) and by Eyles and Kocsis (1989a, b) as braided stream sediments. Poorly to moderately sorted gravels with crude horizontal stratification and weak imbrication (Unit 1, Section 8914A, Appendix B) occur at the top of the pay gravel sequence. Gold values are highest in the lower 3 to 5 metres over bedrock and range from about 4 to 9 grams per cubic metre.

Gold-bearing paleochannel gravel at both Mary and Alice creeks is stratigraphically overlain by a thick succession of Pleistocene sediments. At the Toop Nugget mine on Mary Creek the gold-bearing gravel is overlain by two diamicton (till) units (Figures 25 and 26B). Inter-till sand and gravel and early postglacial gravel also contain some gold, probably reconcentrated from underlying units. Glacial meltwaters have incised a channel and removed much (at least 20 metres) of the overburden. In contrast, gold-bearing gravel at the nearby Alice Creek mine is overlain by about 30 metres of overburden (Figure 26A). The lower part of the overburden sequence consists of horizontally stratified sands and gravels (Units 2 to 8, Section 8914A, Appendix B) interpreted as low-energy, braided stream deposits overlain by a thick diamicton (Units 9 to 11, Section 8914A) inferred to be a basal melt-out till. Planoconvex sand lenses at the base of this diamicton are interpreted as subglacial meltwater channel deposits (Unit 8, Section 8914A). A sequence of coarse, braided stream sands and gravels (Unit 12, Section 8914A) separates this till from an overlying diamicton complex, and is correlative to interdiamicton gravels at Mary Creek (Section 8915A). The overlying diamicton complex (Units 13 to 15, Section 8914A) is interpreted as a series of glacially derived, debris-flow units with interbedded glaciolacustrine sediments. These are capped by well-developed basal till (Unit 16, Section 8914A) and finally by a colluviated diamicton with soil development (Unit 17, Section 8914A). At the North Wall section (8914B) the upper diamicton complex is dominated by glaciotectonically disrupted sand, silt and clay interbeds originally deposited in a glacial lake.

A large valley-fill sequence (Section 9016, Appendix B) has been exposed by Holocene erosion along upper Grouse Creek (Figures 4 and 7, Location 17). Cobble and boulder gravels at the base of the exposure (Unit 2) are interpreted to be high-energy, stream channel deposits. They are overlain by 16 metres (Units 3 to 13) of interbedded sands and gravels inferred to be glaciofluvial braided stream deposits. Units 14 to 20 consist of fine sands, trough cross-bedded towards the base and mainly horizontally bedded in the upper part. Beds thin up-section and some are normally graded, indicating deposition by settling from suspension.

The over-all fining-upward sequence reflects a decrease in energy, probably due to the gradual filling and eventual abandonment of the channel as glaciers receded from the area. The age of the gravels is unknown but as they do not underlie till, they are interpreted to be glaciofluvial gravels deposited during ice retreat. However, several unconformities within the sequence may represent substantial periods of time and some of the lower gravel units may therefore have been deposited prior to the last glaciation. In such a case, till from the last glaciation may have been eroded by the high-energy, channel gravels and consequently is not preserved.

Auriferous paleochannel gravels are exposed along the Little Swift River near its confluence with the Swift River (Location 18, Figures 2 and 6). The gold-bearing gravels are oxidized, crudely stratified and underlie a thick overburden sequence (Section 9018B, Appendix B). They are interpreted as braided stream gravels deposited in a channel system that was substantially wider than the present Little Swift River, based on the extent of outcrop at the site. The overburden sequence at this site consists mainly of glaciofluvial and glacial deposits. Unoxidized, horizontally bedded gravels (Units 6 and 7) overlying the gold-bearing gravels are interpreted as proglacial, braided stream sediments deposited during the advance of glaciers into the region. The thick (12 metres) diamicton sequence on top of the glaciofluvial gravels (Unit 8) is interpreted as till and associated sediments deposited by the glaciers that eventually over-rode the region. The capping silts and fine sands (Unit 9) comprise a thin glaciolacustrine deposit that formed in a small glacial lake occupying this part of the Little Swift River valley immediately after deglaciation.

The Morehead Creek (Figures 2 and 12, Location 19) buried-valley deposits consist of a complex sequence of sand and gravel fining upward into a succession dominated by clay, silt and fine sand. The sequence records gradual infilling and eventual abandonment of the channel, probably during the last interglacial period. Pebbly gravels (Units 1 to 3, Section 8919, Appendix B) dominate the lower 20 metres of this section and are interpreted to be the deposits of a braided stream. The gravels form broad channel-structures indicating an apparent paleoflow toward the north, possibly draining the Mount Polley upland area. Extensive faulting in these units suggests that they have a glacial affinity. The channel gravels are overlain by a thick sequence of coarsening-upward silts and sands (Unit 4) deposited in a relatively quiet water environment, possibly glaciolacustrine. Large-scale foreset bedding in the overlying pebbly sands (Unit 5) reflects deltaic progradation at the site and the overlying horizontally bedded to trough crossbedded gravels (Unit 6) are interpreted as distributary channel (topset) deposits. Capping deposits in this section are two fining-upward sequences of horizontally stratified sand, silt and clay (Units 7 to 10) that were probably deposited during a second transgressive phase of the glacial lake. The entire sequence stratigraphically underlies till deposited during the last glaciation and the lower gravels are therefore probably Middle to Late Wisconsinan.

There is a high probability that other rich, buried, large-valley placer deposits occur in the Cariboo region and possibly other areas of British Columbia. The identification and testing of these paleovalleys should be a major focus for the placer industry. An example of an exploration program of this type was recently provided by the Malaysian Mining Corporation in the Sovereign Creek area (*see* Site 52). The area has excellent potential for a large-volume buried paleochannel placer deposit of interglacial or preglacial age. The buried valley is separated from the modern Sovereign Creek valley by a bedrock high. It was originally identified by interpretation of satellite data (Reimchen, 1990). An extensive drilling program was conducted on the property in an attempt to delineate the extent and size of the deposit. Gold-bearing gravels associated with the buried paleochannel system, identified by more recent drilling, overlie bedrock and are overlain by diamicton and silty clay units interpreted, respectively, as till and glaciolacustrine sediments (Levson *et al.*, 1993b).

BURIED-CHANNEL DEPOSITS WITHIN MODERN VALLEYS

Buried-channel gravel deposits in modern valleys are commonly exploited placers. The paleochannels may occur directly underneath, or adjacent to, modern alluvial channels. Buried channels adjacent to modern streams are often segmented by recent erosion and their lateral extent is therefore often difficult to define. Paleochannels below modern streams commonly, but not always, parallel the modern stream course and may be deeply buried by alluvium and glacial deposits. In addition, these paleoplacers may be difficult to mine because of groundwater or surface water problems. Similarly, paleochannel placers in these settings can only be observed during periods of active mining when groundwater is continuously pumped from the workings. Two examples of paleochannel deposits in modern valleys are discussed below.

Ballarat Mine: Gold-bearing deposits at the Ballarat mine (Figures 4 and 7, Location 29) fill an ancient bedrock channel adjacent to Williams Creek, which is one of the richest gold-producing streams in British Columbia. A detailed description of the geology at this mine was provided by Levson *et al.* (1990) and is summarized in Chapter 5 (Location 29). The lowest exposed gravel (Figure 27) in the Ballarat pit is a moderately sorted, clast-supported, very compact pebbly gravel generally with a fine to medium sand matrix. Multiple scour and channel-fill structures indicate deposition in a braided river system. Lithologic analysis of these gravels suggests that they were not derived solely from a local tributary, but rather were deposited in the main valley. The gravel contains up to approximately 2 grams of gold per cubic metre and, in general, gold content increases with depth. Seismic, drilling and excavation results indicate that a variable gravel unit on the order of 10 metres thick is present below the lowest exposed gravel beds.

Discontinuous, thin (<3 metres thick), diamicton beds overlie bedrock highs along the south and north sides of the paleochannel. They exhibit sedimentary characteristics typical of modern debris-flow deposits such as poor sorting, disorganized fabric, gradational bed contacts and folded and

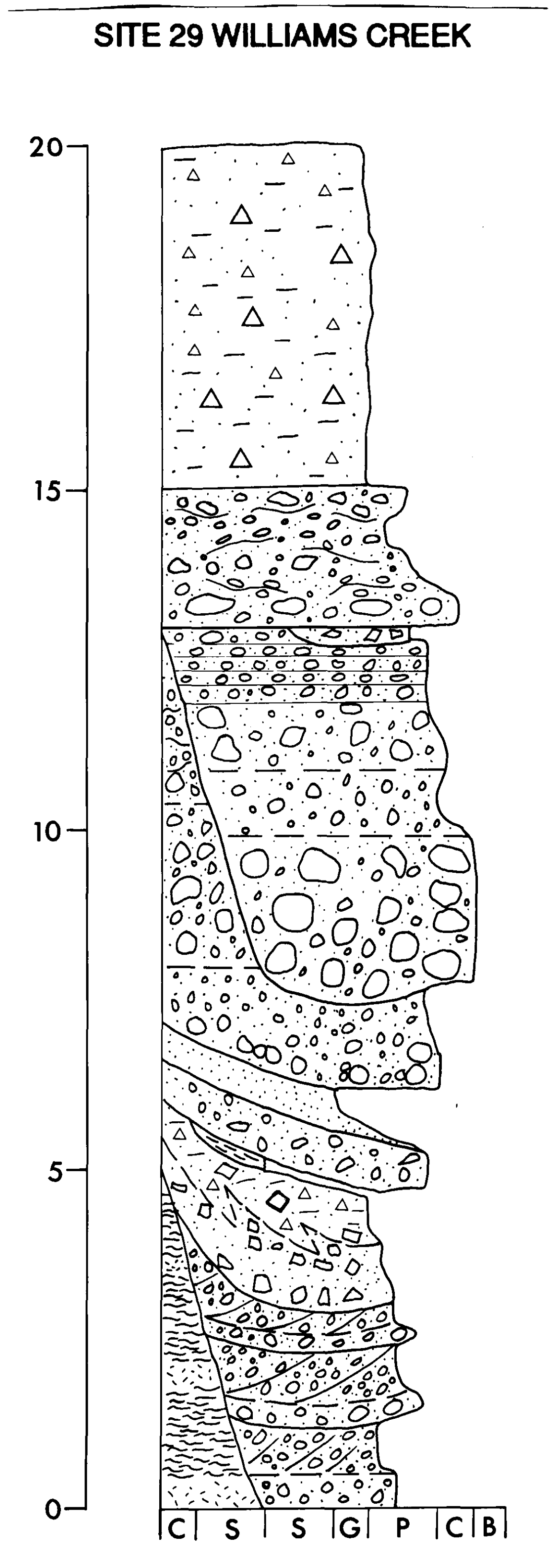


Figure 27. Stratigraphic section of paleochannel gravels overlain by till at the Ballart mine along Williams Creek (Location 29). Gold occurs mainly in the lowermost gravels, the coarser, overlying gravel units being glaciofluvial in origin. *See* Figure 14 for legend. Horizontal scale indicates mean grain size: C-clay, S-sand, Si-silt, G-granule, P-pebble, C-cobble, B-boulder.

boudinaged beds (Bull, 1972; Kochel and Johnson, 1984). Deposition of these locally derived debris-flow sediments along the margins of the channel was probably coeval with fluvial sedimentation in the channel centre.

The lower gravels are unconformably overlain by chaotic to weakly imbricated, poorly sorted, large-cobble to boulder gravels with a sand to pebble matrix (Figure 27). They are clast supported and exhibit crude horizontal to gently inclined stratification which becomes more horizontal in the upper parts of the unit. The number of striated and distally derived clasts also increases toward the top. The poor sorting, coarse size of clasts, and the presence of striated and distally derived clasts suggests that they are glaciofluvial in origin. Deposits of this type are typical of proximal, braided gravel-bed rivers in glacial environments (Church and Gilbert, 1975). Gravelly, braided streams are characterized by crude subhorizontal stratification (Hein and Walker, 1977). The increase in striated clasts toward the top of the unit may indicate the proximity of glacial ice, an interpretation which is further supported by the overlying massive diamicton, interpreted as till.

The gold-bearing gravels and associated debris-flow deposits that fill the paleochannel at the Ballarat mine were probably deposited in the last interglacial period. They are overlain by a complex succession of alluvial fan deposits, ice-proximal gravels and till (*see* below). Although the lower contact of the till is erosional, the underlying sand and gravel deposits were largely protected from the erosive effects of northerly flowing glaciers by Mount Conklin which lies immediately southeast of the mine. Currently, economically viable gold placers occur only in fluvial and debris-flow sediments that were deposited prior to the last glaciation. Gold concentrations in till and enclosed sediments are low (0.1 to 0.2 gram per cubic metre; B. Ball, personal communication, 1989).

Lightning Creek (Gallery Resources Ltd.) Mine: Placer gravels in a buried channel adjacent to Lightning Creek (Figures 3, 11 and 28, Location 24) are currently being mined (Plate 9). The gold-bearing gravels are about 10 metres thick. A geologic cross-section of the gold-bearing gravels is provided in Figure 29. Detailed descriptions of each unit are provided in Section 9024A (Appendix B). The highest gold concentrations occur in the lower 5 metres of gravel that sit unconformably on bedrock (Units 1 to 4, Figure 29). The auriferous sequence is conformably overlain by about 25 metres of sand and gravel (Figure 28) with relatively low gold concentrations, interpreted as glaciofluvial braided stream deposits. The auriferous basal gravels are interpreted as interbedded debris-flow and fluvial deposits. The combination of the two types of deposits in this setting indicates a high-energy, confined, braidplain environment with input of sediment from the valley sides. The debris-flow deposits are coarse, poorly sorted, massive to normally graded and dominated by large pebbles with about 5% boulders and 10% cobbles. These characteristics, combined with a disorganized to crudely imbricated fabric and a low proportion of clay in the matrix, suggest deposition from noncohesive flows. Normal grading in some beds is indicative of hyperconcentrated flood-flows (Smith, 1987). Large, trough-

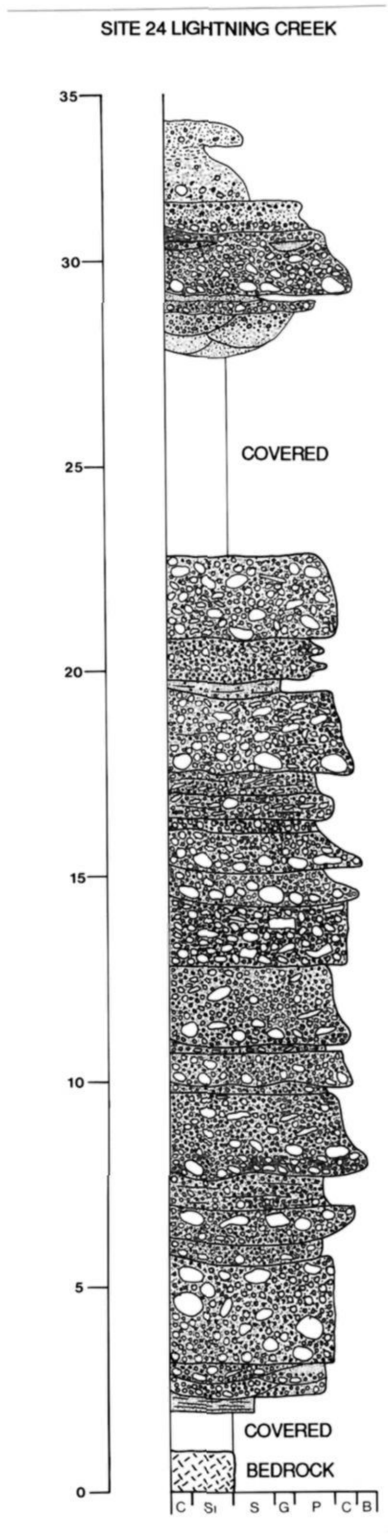


Figure 28. Composite stratigraphic column of buried channel deposits in the Gallery Resources mine in the Lightning Creek valley (Location 24). Gold is most concentrated in the lower 5 metres and in coarse lag gravels at the top of the sequence, although auriferous beds occur throughout. Most of the gravels are interpreted as glaciofluvial braided stream deposits. (*See* Figure 14 for legend.) Horizontal scale indicates mean grain size: C-clay, S-sand, Si-silt, G-granule, P-pebble, C-cobble, B-boulder.

shaped beds of moderately to well-sorted, medium to large-pebble gravel in the upper part of the gold-bearing sequence, reflect increased fluvial reworking and channelling of the flows. Stratification in these deposits is defined by cobble and boulder beds and by lenses of oxidized, openwork pebble gravel (*e.g.*, Units 3 and 7, Figure 29). Cobble and boulder concentrations at the base of channelled gravel beds (Plates 8 and 9; Figure 29) are believed to be the most productive gold-bearing facies.

Other bedrock channels along the margins of present valley bottoms may represent largely untapped sources of placer gold throughout the Cariboo region and elsewhere in British Columbia. Exploration should focus on regional airphoto interpretation, detailed seismic cross-sections and large-diameter drilling for the identification and evaluation of these hidden deposits.

PALEOALLUVIAL FAN AND FAN-DELTA SETTINGS

Paleoalluvial fan placers have been recognized at two major mines in the Cariboo (Figures 2 and 4, Locations 21 and 29). The gold-bearing deposits at both sites are capped by till deposited during the Late Wisconsinan. Gold within the paleofan sequences is believed to be mainly local in origin as indicated by its angularity and the abundance of locally derived clasts in the associated sediments. Gold values are relatively uniform throughout the alluvial fan sediments but they generally contain substantially less gold per cubic metre than higher grade fluvial deposits. Alluvial fan placers throughout the world are known to contain significantly lower gold grades and larger volumes than stream placers (Bliss *et al.*, 1987). The gold occurs in both poorly sorted debris-flow sediments and interstratified fluvial gravels and sands (Krapez, 1985). Gold concentrations are commonly highest at sites of subsequent fluvial degradation (Buck and Minter, 1985).

At the Spanish Mountain mine (Figures 2, 12 and 23, Location 21), gold is found in poorly sorted and crudely stratified coarse gravels interpreted as debris-flow deposits (Plate 19). Interbedded lenses of better sorted gravel, sand and silt are deduced to be fluvial channel deposits. The gold-bearing gravel is overlain by a poorly exposed diamicton sequence interpreted as till and glacially derived debris-flow deposits, suggesting that the placer gravels predate the last glaciation (Figure 23). The gold-bearing sediments are mainly locally derived and interpreted as alluvial fan deposits. Gold content is generally consistent throughout the mined sequence, averaging about 1 gram per cubic metre, not including gold finer than 100 mesh (0.149 millimetre), and the gold appears to be locally derived (McKeown and McKeown, 1989).

At the Ballarat mine, auriferous alluvial fan and fan-delta sediments stratigraphically overlie the paleochannel gravel described earlier (Figure 30). The fan and fan-delta sediments consist of a complex sequence of sand and gravel with gold concentrations up to approximately 2 grams per cubic metre. Lithologic analysis of the lower gravel in the sequence (Unit 4, Figure 30) and the general northerly dip of beds, indicate that they were derived almost entirely from

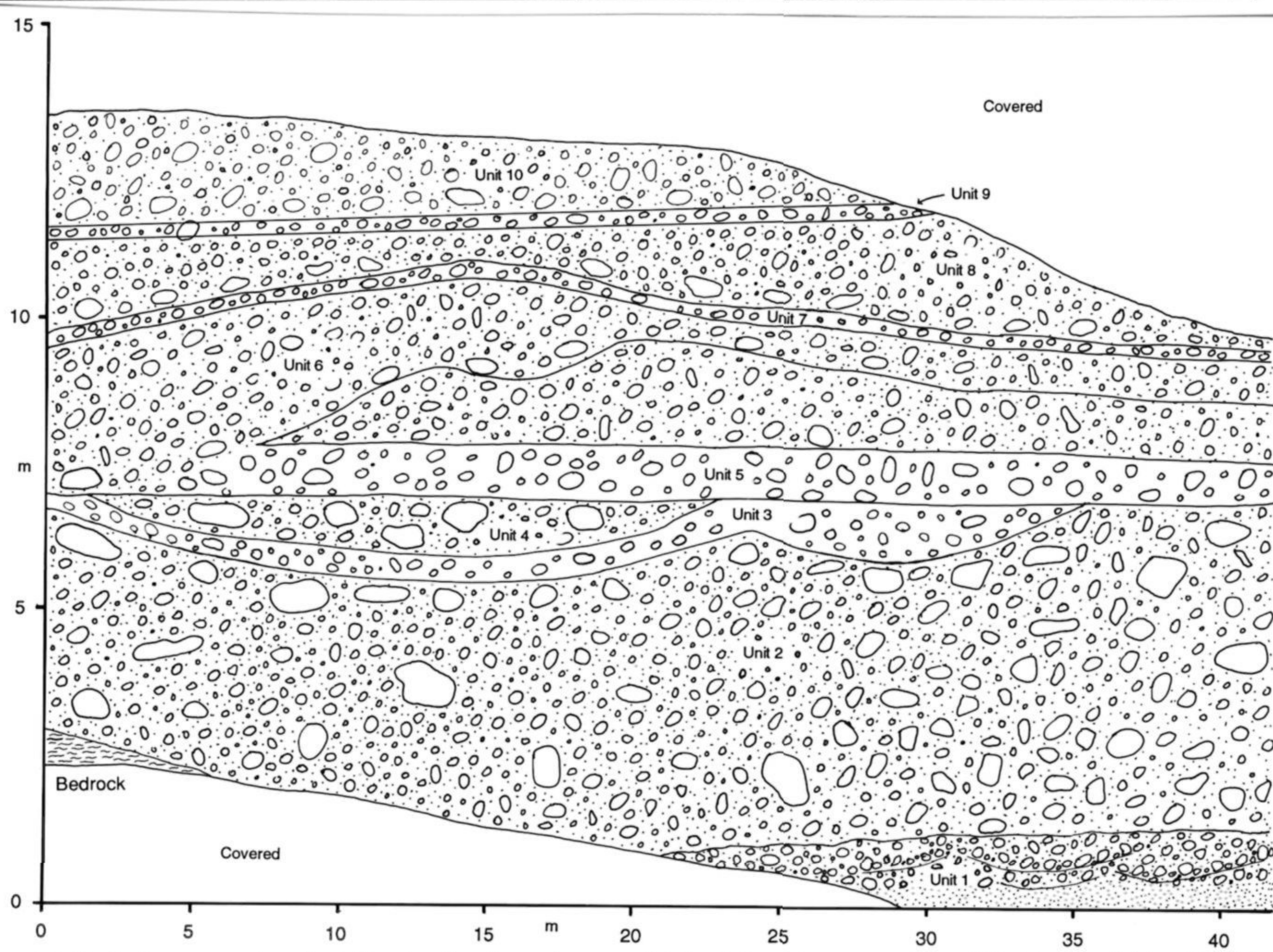


Figure 29. Geologic cross-section of gold-bearing, basal gravels exposed at the Gallery Resources mine on Lightning Creek (Location 24). Gold occurs in interbedded debris-flow and fluvial deposits at the base of the sequence (Units 1 and 2) and in trough-shaped, coarse gravel beds interpreted as channel lag deposits (*e.g.*, at the base of Units 3, 6 and 8); *see* Figure 14 for legend.

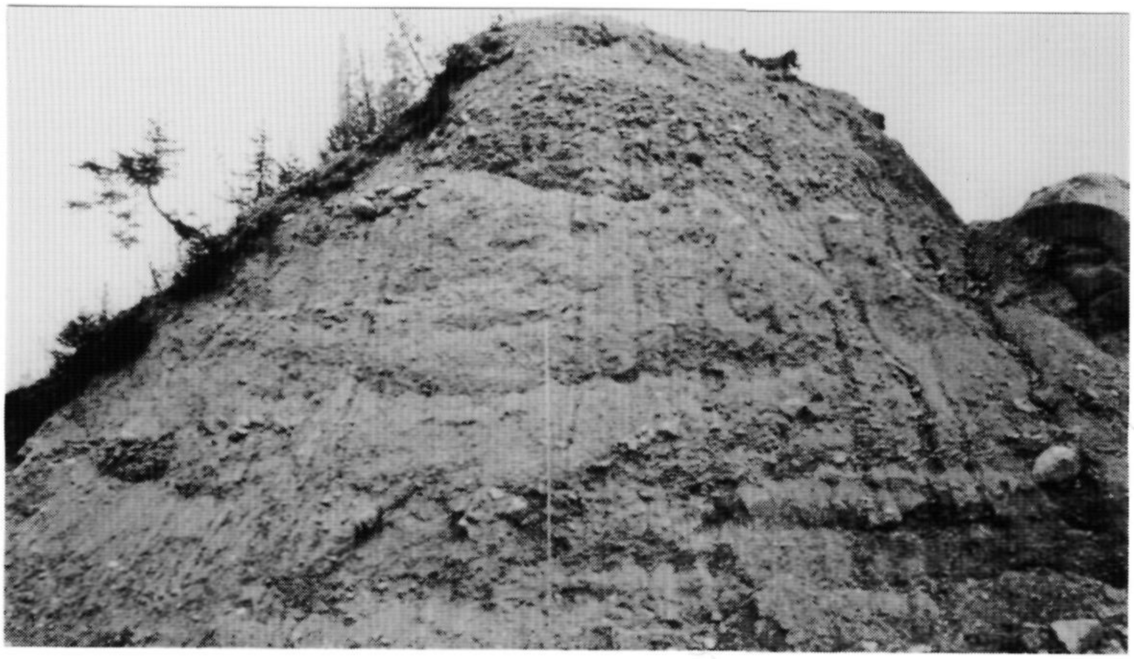


Plate 19. Auriferous, locally derived, poorly sorted, crudely stratified, coarse gravels and diamicton interpreted as debris-flow deposits with interbedded lenses of fluvial gravel, sand and silt at the Spanish Mountain McKeown mine (Location 21). The gold-bearing sediments are interpreted as pre-Late Wisconsinan alluvial fan deposits. Rod is 4 metres high.

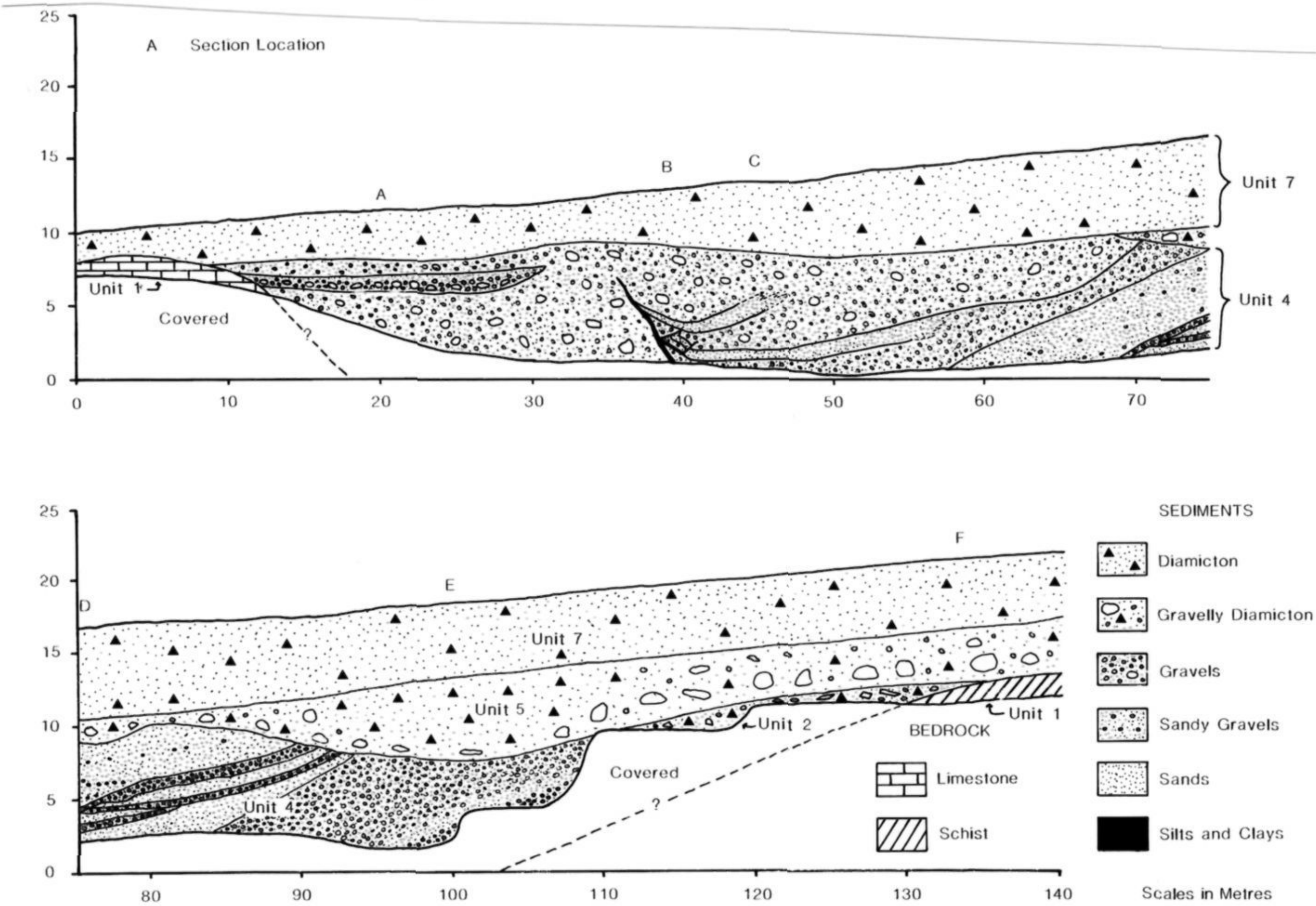


Figure 30. Geologic cross-section of paleofan-delta deposits at the Ballarat mine, Williams Creek (Location 29). Both delta foreset beds (Unit 4) and debris-flow deposits (Units 2 and 5) are auriferous. The upper diamicton (Unit 7), interpreted as a till, also contains gold but is not mineable.

a small tributary drainage to the south. The characteristically steep (up to 25°) and consistent dip of massive gravel beds in Unit 4 (Figure 30), sharp planar bed contacts, lateral continuity of strata for several metres and the topographic setting all suggest deposition in a fan-delta environment (Plate 20). The steeply dipping gravel beds (foresets) pinch out or flatten in the down-dip direction and grade up-dip into overlying (topset) gravel beds. Sedimentary structures representative of this unit, such as massive and normally graded sand, horizontally laminated silt and fine sand, climbing ripples and syndepositional deformation structures, are common in subaqueous environments. Other typical features such as load, flame and injection structures indicate rapid deposition onto saturated sediments. Sand intraclasts, local concave scouring, convoluted bedding, faults and other deformation structures probably formed as a result of syndepositional slumping of over steepened foresets. Massive to normally graded sand and gravel which grade downslope into sand and silt beds may be sediment gravity-flow deposits. Drainage near the Ballarat mine must have been impeded, possibly as a result of the onset of glaciation, to allow fan-delta progradation over older fluvial sediments.

Where depth to bedrock increases substantially, presumably near the fan centre, fining-upward channel-fill gravel sequences with erosional lower contacts probably represent deposition in main channels (Figure 27). Near the fan margins, where bedrock rises closer to the surface, the uppermost deposits in the gold-bearing sequence are clast-supported, poorly sorted diamictons (Unit 5, Figure 30). They exhibit crude horizontal bedding, minor openwork pebbly interbeds, weak imbrication and normal grading, sometimes with a thin, inversely graded basal zone. These characteristics are typical of debris-flow deposits (Burgisser, 1984; Kochel and Johnson, 1984). Sorted beds indicate some fluvial activity, probably between debris-flow events. Lithologic and fabric data indicate that the flows originated from the highlands to the southwest. The increase in locally derived debris-flow material, possibly due to a reduction in vegetative cover associated with glaciation, resulted in the progradation of alluvial-fan sediments over the area.

SURFICIAL DEPOSIT SETTINGS

GLACIAL PLACERS

Glacial processes that result in the deposition of tills, typically do not allow for the removal of light minerals or the concentration of gold and other heavy minerals (Herail *et al.*, 1989a). Dilution of gold concentrations in glacially transported and deposited materials also occurs due to mixing of distally and locally derived sediments. However, tills

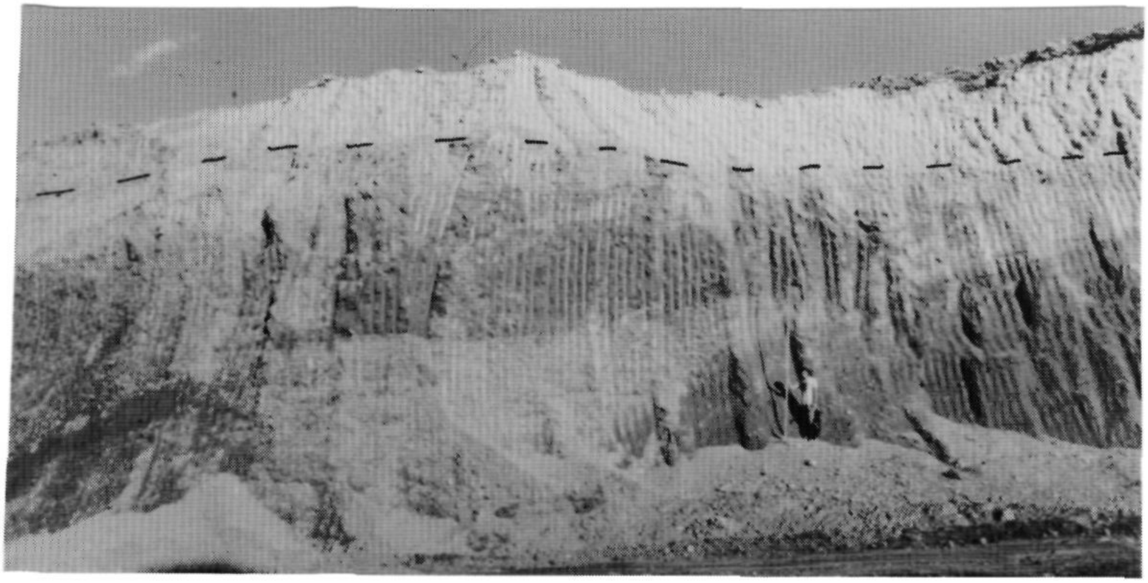


Plate 20. Gold-bearing fan-delta sediments unconformably overlain by till at the Ballarat mine (Location 29). The fan-delta sediments contain up to approximately 2 grams of gold per cubic metre. (Paleoflow from right to left.)

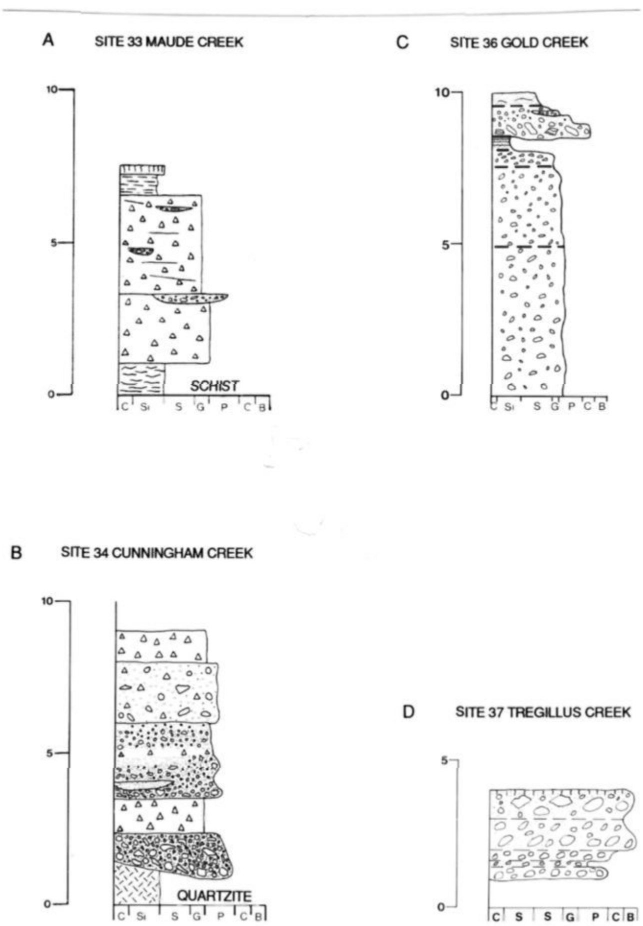


Figure 31. Stratigraphic sections representative of Late Wisconsinan glacial and glaciofluvial placer deposits in the Cariboo region. A) Stratified diamicton, interpreted as glacially derived, debris-flow deposits overlying massive diamicton (till) and bedrock at the Maude Creek mine (Location 33); B) Glacial diamicton overlying interbedded debris-flow deposits and auriferous, channellized, sands and gravels at the Cunningham Creek mine (Location 34); C) Glaciofluvial gravels at Gold Creek (Location 36), with gold most concentrated in the upper lag gravel deposit; D) Coarse, auriferous, lag gravels overlying barren pebble-gravels in a glaciofluvial deposit at the Tregillus Lake mine (Location 37). *See* Figure 14 for legend. Horizontal scales indicate mean grain size: C-clay, S-sand, Si-silt, G-granule, P-pebble, C-cobble, B-boulder.

and glacially derived debris-flow deposits, originating from glaciers that have over-ridden older placer, bedrock or saprolitic gold sources, may be locally productive where gold concentrations in the original deposits were exceptionally high (Sutherland, 1985; Maurice, 1988; Shilts and Smith, 1988; Levson and Giles, 1991; Pizey, 1991).

For example, at Cunningham Creek (Figures 2, 8 and 31, Location 34), tills and associated deposits carry mineable quantities of gold. Glaciers flowing down the Cunningham Creek valley probably incorporated the gold from rich paleochannel placers up-valley. Diamicton beds occurring at the surface in this area (Units 1 and 2, Section 8934, Appendix 2) are interpreted as basal tills. The surface diamicton at the mine site contains approximately 0.3 to 0.7 gram of gold per cubic metre. The diamictons are over consolidated and clasts exhibit frequent striations and valley-parallel fabrics. Crude stratification in some beds and thin sandy laminae and silt lenses suggest a melt-out origin, although a glacially derived debris-flow origin for some beds can not be ruled out. Gold concentrations are highest in the upper diamicton and there is no noticeable increase over bedrock in most areas, suggesting an up-valley, rather than immediately local source. Small, isolated pockets of gravel, containing up to 60 grams of gold per cubic metre, may be blocks of the original gold-bearing gravels that were incorporated into the ice (*e.g.*, by basal freezing) and redeposited down valley. Gravel lenses, with interbedded diamicton, stratigraphically underlie till and also contain gold. These are interpreted to be interbedded stream and debris-flow deposits associated with proglacial, or possibly subglacial, glaciofluvial channels paralleling Cunningham Creek.

At Maude Creek (Figures 4 and 7, Location 33) massive, compact diamicton (Figure 31A) overlying schistose bedrock, contains numerous local, angular, muscovite-biotite schist clasts as well as some striated and erratic clasts and is interpreted as a basal till. A crudely stratified diamicton overlies the till. The dip of beds and clast orientations suggest a southerly paleoflow. This unit is believed to have originated as a series of debris flows deposited along the margins of a down-wasting glacier in the valley centre to the north and west. Oxidized silts and interbedded peats and diamicton overlie the debris-flow deposits and a thin veneer of peat covers the bench. These units represent postglacial lacustrine and bog deposits that developed on the upper bench level prior to deeper stream incision in the valley. The bench is locally surfaced by a thin (<1 metre), poorly sorted gravel, interpreted as postglacial, fluvial, terrace deposits.

GLACIOFLUVIAL PLACERS

Deposition of glaciofluvial gravels commonly occurs in aggradational braided stream environments with high sedimentation rates. Long periods of erosion or channel stability, allowing for selective deposition of gold and other heavy minerals, are uncommon in this environment. Channel erosion is localized and occurs within an overall aggradational setting due to the influence of sediment input from the nearby glaciers. Significant concentrations of placer minerals are restricted to locally occurring coarse gravel lags that sometimes cap glaciofluvial sequences that are otherwise mainly nonauriferous. These lag deposits presumably formed during periods of temporary stability, transitional between glaciofluvial stream aggradation and postglacial stream incision. In rare cases, glaciofluvial placer deposits may form in high-energy, subglacial meltwater conduits but these placers are usually small. Large volume esker deposits, for example, have not been found to contain significant quantities of gold in the study area. Economic glaciofluvial placer deposits also may occur along the base of meltwater channels where gold was concentrated from the sediments originally filling the meltwater channel valley. In virtually all documented cases, glaciofluvial placer deposits (from both ice-marginal and subglacial settings) occur down-flow from areas where glaciofluvial streams have eroded gold from older auriferous placer deposits. The resultant glaciofluvial deposits are invariably of a lower grade than preserved remnants of the original placers.

One of the largest mines in the Cariboo exploiting glaciofluvial gravels is along the northeast side of Tregillus Lake (Figures 3, 10 and 31D, Location 37, Plate 21). The auriferous gravels contain average gold concentrations of approximately 0.15 to 0.35 gram per cubic metre. The gold-bearing deposits are poorly to moderately sorted cobble gravel with clasts up to 2 metres in diameter overlying small to large-pebble gravel. The mined gravels are interpreted to be glaciofluvial gravels deposited during deglaciation. The wide range in clast lithologies and sharp changes in grain size and sorting from bed to bed support this interpretation. The presence of hummocky topography in the area suggests that stagnating ice blocks were associated with deposition of the glaciofluvial gravels during deglaciation. Gold within the gravel was probably derived from older placer deposits upstream, possibly auriferous sediments underlying lodgement till at the south end of Tregillus Lake (Eyles and Kocsis, 1988). Gold is most concentrated in the coarse gravel in the uppermost 1 to 2 metres, reflecting the typical association between coarse lag gravels and placer gold concentrations.

At Gold Creek (Figures 2 and 6, Location 36) gold occurs in glaciofluvial gravels that floor a small meltwater channel near the south end of Hay Lake. As glacial deposits would have obscured any small pre-existing valleys, the meltwater channel must have been cut during deglaciation. Gold is most concentrated at the base of a coarse gravel that occurs within a few metres of the surface in the meltwater channel (Figure 31C; Section 9036B, Appendix B). Gold values of approximately 1.3 to 2.6 grams per cubic metre are reported for these gravels. They unconformably overlie horizontally laminated silts and clays that contain dropstones up to boulder size and are interpreted as glaciolacustrine deposits. The auriferous gravels contain silt and clay rip-up clasts from this unit. The coarse cobble bed at the base of the upper gravels is interpreted as a lag gravel resulting from erosion of pre-existing deposits during incision of the meltwater channel. Erosion to greater depths was presumably inhibited by the underlying resistant silt and clay strata. Older gravel units at this site consist of well- sorted, well-rounded gravels of fluvial or glaciofluvial origin. The age

Plate 21. Poorly sorted, cobble to boulder, glaciofluvial gravels mined within a few metres of the surface at Tregillus Lake (Location 37). Underlying pebble gravels are largely nonauriferous. Pick is 65 centimetres long.

of these gravels is unknown although weathering of granites and local cementation, particularly in the lowermost gravels, suggest a relative age significantly greater than the overlying sediments.

Gold concentrations in some glaciofluvial deposits have been increased as a result of colluvial processes to a grade sufficiently high to allow mining. Such is the case in the lower Pinus Creek area (Location 38; Figures 4 and 7) where the gold-bearing deposits are believed to be glaciofluvial gravels derived from a number of meltwater channels that funnel into the site. The glaciofluvial sands and gravels are unconformably overlain by crudely stratified diamicton of probable colluvial origin. Gold concentrations are highest near the surface in the upper few metres, particularly on wet sites (north and east-facing slopes) where colluvial enrichment processes are most active. Some of the gold at this site may also have been transported into the area by glaciers and subsequently reconcentrated from the till by glaciofluvial activity. A small hydraulic mine on upper Pinus Creek in the 1920s produced about 2.5 grams per cubic metre with nuggets up to 70 grams in weight (Johnston and Uglow, 1926). The gold was recovered from glaciofluvial boulder-gravels and was believed to have been concentrated from glacial debris by meltwater activity.

Large-volume glaciofluvial gravel deposits of relatively low grade have been mined successfully in other glaciated areas in the world for example, New Zealand, where they occur below the water table and have been mined with large dredges (Williams, 1974; Pizey, 1991). Exploitation of glaciofluvial placer deposits is also known from the Ivalojoki area in Finnish Lapland (Saarnisto *et al.*, 1991) and the Andes Mountains of Peru and Bolivia (Herail *et al.*, 1989a).

HIGH TO INTERMEDIATE-LEVEL TERRACES

The high elevation of terrace gravels occurring well above modern river levels suggests that they were formed during deglaciation or in early Holocene times. They are mined at a several localities in the Cariboo (Figures 2 and 4, Locations 40 to 45 and 48). It is often difficult to differentiate glaciofluvial gravel deposited in kame terraces along lateral ice-margins from proximal, proglacial stream sediments deposited shortly after local deglaciation. Aggradation of glaciofluvial gravels during and immediately after deglaciation is common due to the input of large amounts of material into the stream system from the retreating glaciers and from recently exposed valley sides. High gold concentrations in aggradational glaciofluvial systems of this type are unlikely. Consequently these gravels form large-volume deposits with low gold concentrations. Placers can accumulate, however, in localized sites where significant stream-channel erosion has occurred during or at the end of the aggradational phase. Sedimentation in these proximal braided streams is characterized by multiple shifting channels resulting in numerous superimposed channel-fill sequences and significant gold concentrations may occur at the base of the channels. For example, in high-terrace gravels along the Quesnel River (Sites 44 and 45), gold concentrations occur mainly in the upper part of the gravel sequences along channel-scour features that are marked by coarse gravels. Deposits with similar gold distribution and sedimentologic characteristics are known to occur in Quaternary terraces in many other placer districts throughout the world. Placer deposits in Quaternary terraces in Bolivia, for example, are characterized by basal lag gravels overlain by trough cross-stratified gravels. Gold contents increase down-section with grades reaching a maximum of 0.6 gram per cubic metre at the base (Herail *et al.*, 1989b).

In the Cariboo, most late-glacial and postglacial, high-terrace gravel sequences that contain significant quantities of gold occur either downstream from older placer deposits from which gold was reworked or at the junctions of major valleys. The high-terrace placers on the Quesnel River, mentioned above (Sites 44 and 45), occur directly downstream from the Bullion mine. The mined deposits are clast-supported, matrix-filled, poorly sorted, moderately to well rounded, pebble to boulder gravels. Gold concentrations occur in large-clast clusters with boulders up to 2 metres in diameter that are associated with scoured channel-forms. These major channel-scour facies were probably deposited during unusually high flow events as indicated by the exceptional size of the boulders. The presence of imbricated clusters and the abundance of fractured clasts indicates bed-load transport in turbulent flows.

The well known effect of enhanced placer accumulation at channel junctions (Mosley and Schumm, 1977; Smith and Minter, 1980; Best and Brayshaw, 1985) is illustrated by a mine at the confluence of the Willow River and Slough Creek (Location 43). The exposed sequence is dominated by crudely bedded, well-imbricated gravels, typical of many terrace gravels occurring on the braidplain of late Pleistocene or early Holocene rivers. Gold at this site was probably recycled mainly from upstream placers in the Slough Creek and Willow River valleys and from tributary streams in these two valleys.

Typical high-terrace gravels (Plate 22; Figure 32), are exposed at a mine on Burns Mountain (Figures 4 and 7, Location 41). The gravels are well stratified, with horizontal, planar and trough crossbedding. They locally contain mineable quantities of gold but elsewhere they are almost barren, despite stratigraphic and sedimentologic similarities between the auriferous and non-auriferous deposits (Figure 33A and B). The presence or absence of gold is believed to be a function of the distribution of older gulch placer deposits in relation to paleoflow directions of the glaciofluvial streams that reworked and, to a certain extent, diluted the older placers. Paleocurrent data indicate that flow was perpendicular to the older streams and consequently gold occurs only downstream of intersections with the paleochannels.

Another example of gold-bearing gravels in a high-terrace setting is provided at a minesite along the Quesnel River northwest of Likely (Location 42). The mined terrace gravels are underlain by a thin, massive, matrix-supported, compact diamicton with horizontal fissility. These basal sediments overlie bedrock and are interpreted as a veneer of Late Wisconsinan till. They are overlain by a fining-upward sequence of crudely stratified cobble gravels overlain by two trough-shaped units of horizontally bedded pebble-gravel and fine to medium sand, and by a unit of horizontally bedded silts and clays (Section 9042A, Appendix B). These sediments are interpreted as channel-fill deposits in a glaciofluvial braided stream. Gold occurs mainly in coarse gravels along the unconformity at the base of the fining-upward sequence, suggesting that it was concentrated during a period of erosion prior to infilling of the channel. The

Plate 22. Typically well stratified and well sorted high-terrace gravels near Burns Creek (Location 41). The gravels are auriferous only where they occur downflow from older gulch placer deposits from which gold was derived. Measuring rod is 4 metres long.

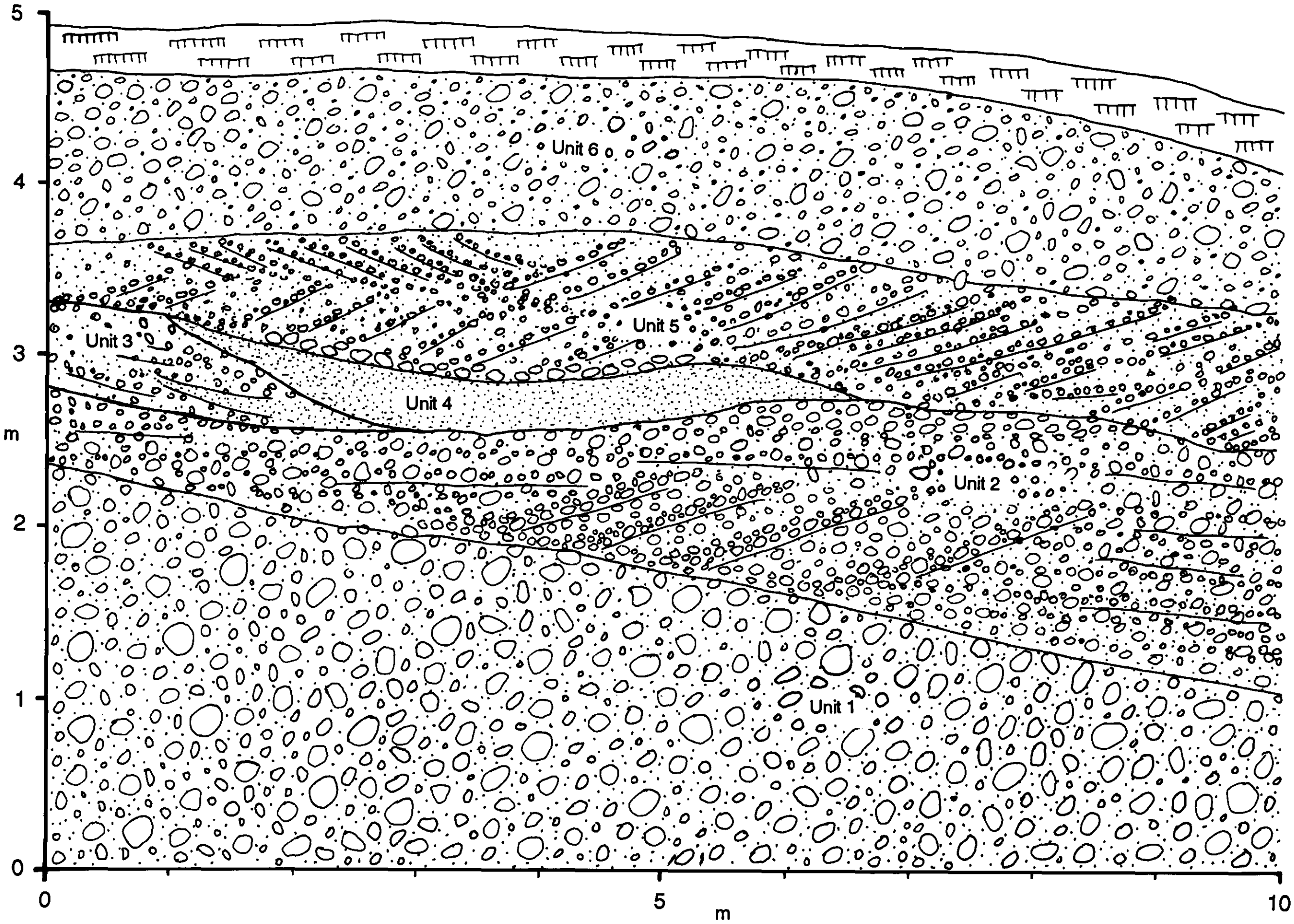


Figure 32. Cross-section of glaciofluvial gravels mined from a high terrace on Burns Mountain (Location 41). The sequence is dominated by massive to crude horizontally bedded, longitudinal bar gravels (Units 1 and 6) with some cross-stratified, channel-fill and transverse bar deposits (*see* Figure 14 for legend).

ward sequence, suggesting that it was concentrated during a period of erosion prior to infilling of the channel. The length and exact timing of the erosional phase are unknown. Channellized pebble-gravels and sands in the upper part of the section are relatively barren and reflect late-stage flow across the terrace. Massive silts, that cap the section but are confined to depressions on the terrace surface, are interpreted to be loess deposits. Gold in the gravels was probably derived by glaciofluvial, and possibly also glacial, erosion from older paleogulch deposits that have been mined from the nearby Excelsior hydraulic pit upslope from this site.

LOW-LEVEL TERRACES

Fluvial terrace deposits, occurring at or near modern river levels, are more readily recognized than other types of surface placer deposits, because of the relatively high degree of preservation of geomorphic features on their surfaces and their sometimes direct association with modern streams. Former channel courses on these terraces may be visible on aerial photographs or can be defined by detailed ground surveys (Teeuw *et al.*, 1991). Surficial placers of this type are mainly allochthonous, fine gold deposits. Their distribution, dependent mainly on the hydrodynamic properties of flowing water, is controlled to large extent by the location and geometry of channels and associated bedforms (Kartashov, 1971). They form in locations where lighter minerals and rock fragments are frequently removed and finer gold is regularly deposited. Typical sites in the Cariboo include point bar settings and inlets to intermittent braid channels on large rivers such as the Fraser (*e.g.*, Locations 46 and 47). Channel thalwegs are sites of deposition of coarser gold in more proximal placers. Gold concentrations in these types of deposits are typically facies controlled with most gold occurring in lag gravels at the base of channel scours and, at the scale of bedforms, in coarse, mainly bar-head, gravel beds in longitudinal bar deposits, in boulder and cobble clusters, and along basal unconformities in transverse-bar sequences. At a smaller scale, gold concentrations are common in zones of altered turbulence and eddy current deposition in the lee of obstructions such as large clasts, and downstream of natural riffles created by bed irregularities.

Low-terrace gravels are currently being mined at several locations on lower Lightning Creek and the Quesnel and Cottonwood rivers (Figures 2 and 3, Locations 46 - 57). The

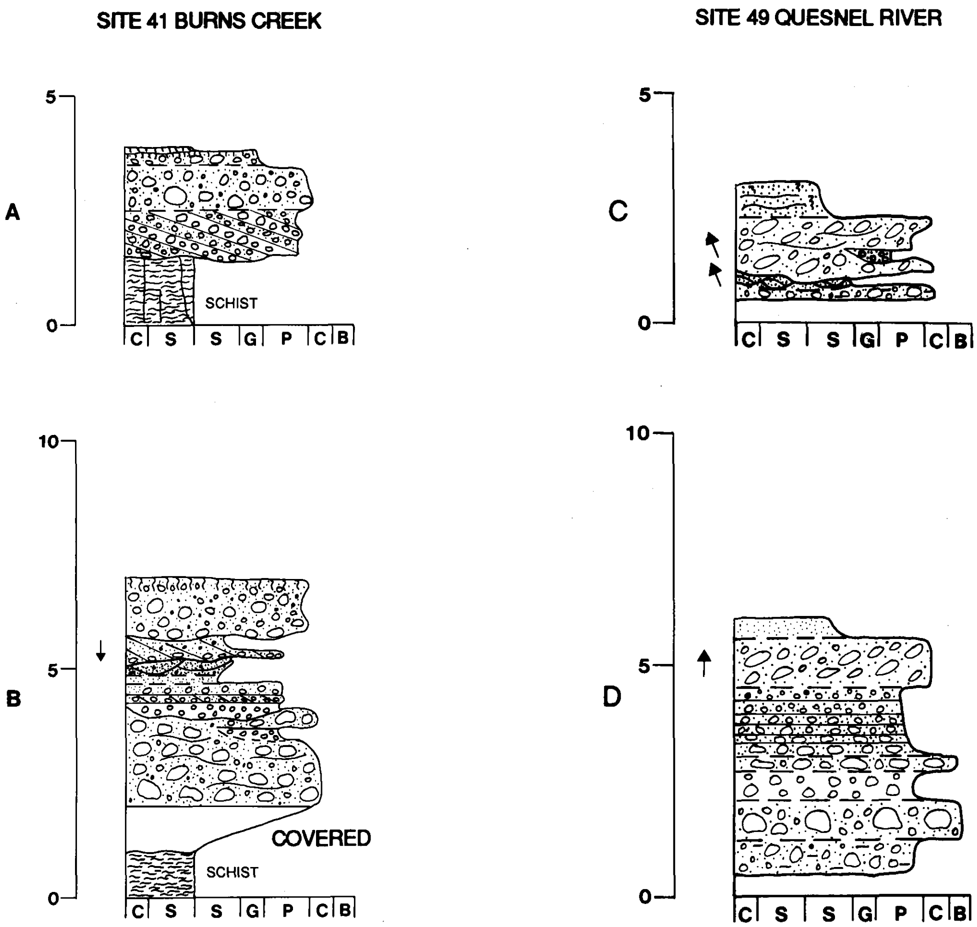


Figure 33. Stratigraphic sections representative of postglacial terrace placer deposits: A) gold-bearing and B) barren high-terrace, glaciofluvial, gravel on Burns Mountain (Location 41); C) and D) Holocene, gold-bearing, low-terrace, fluvial placers on the Quesnel River (Location 49). Horizontally bedded, longitudinal bar, gravels are overlain by overbank sands. *See* Figure 14 for legend. Horizontal scales indicate mean grain size: C-clay, S-sand, Si-silt, G-granule, P-pebble, C-cobble, B-boulder.

development of numerous mines along the lower reaches of these streams is only in part a reflection of geology as relatively coarse gold deposits in upper reaches have been mostly mined out. Progressively finer gold is carried farther downstream where its distribution is strongly controlled by the depositional environment. Gold concentrations occur, for example, in former channel thalwegs, at channel junctions, on former point bar margins and around flow obstacles such as large boulders.

Low-terrace placers deposited in both braided and meandering stream environments have been identified in the Cariboo. Sediments interpreted as braided stream deposits typically consist of well-sorted, horizontally stratified, imbricated, well-rounded pebble to cobble gravels. At most sites the terrace gravels are separated from bedrock or older sediments by pronounced erosional unconformities (Plate 23) along which gold is often concentrated. Planar and trough crossbedded gravel beds occur locally. Sandy interbeds and lenses are common and gravel sequences are usually capped by up to 1 metre of overbank fines (Figures 33C and D; Plate 24). The latter commonly exhibit weak horizontal laminations and contain abundant organic material. Scoured lower contacts in gravel beds are frequently overlain by concentrations of coarse clasts. The coarse grain-size of some beds, well-developed clast imbrication, abundance of well-rounded clasts and scoured lower contacts are indicative of high-energy, turbulent, channellized flows. Channel bedforms include longitudinal and transverse bars that are represented, respectively, by horizontally bedded and planar crossbedded gravels. Trough crossbedded gravels are interpreted as minor channel-fill sequences. Channel lags formed during periods of relative channel stability are primary placer targets. Overlying gravel bar sequences formed during aggradational phases, typically contain less gold.

Several mines along the Cottonwood River are typical of meandering-river terrace deposits. The exposed sand and gravel deposit at Location 53 (Figures 3 and 11), for example, is interpreted as a meandering stream, channel-fill sequence. The lowest exposed sand and gravel beds contain numerous intraclasts of silt and fine sand derived from the underlying deposits. Their lower contact is erosional and marked by a lag gravel. Epsilon crossbeds in the sands and gravels dip northward and suggest deposition in a point bar on the southern margin of a meandering channel. This interpretation is supported by the overall fining-upward sequence, a lateral coarsening of the deposits in the down-dip direction (towards the channel centre) and westerly paleoflow data (perpendicular to the dip of beds). Crude horizontal bedding and trough crossbedding in overlying units are interpreted, respectively, as longitudinal bar and cut-and-fill deposits formed in a subsequent, possibly braided,

Plate 23. Horizontally bedded, pebble to cobble-sized, low-terrace gravels unconformably overlying deformed glaciolacustrine sediments along the Cottonwood River (Location 53).

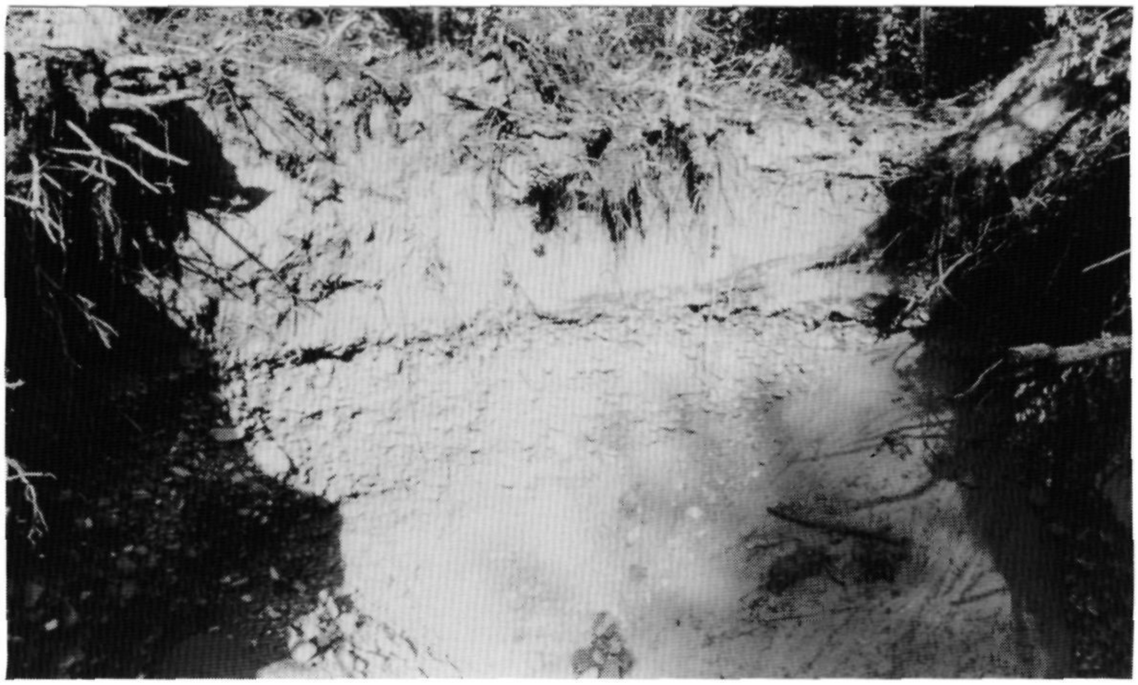


Plate 24. Sandy overbank deposits, up to 1 metre thick, capping horizontally bedded, low-terrace gravels on the Quesnel River (Location 49).

phase of the stream when the terrace surface was planed. Horizontally bedded silts and fine sands capping the sequence are inferred to be overbank deposits. Evidence of scroll bar deposits and abandoned channel cutoffs on terrace surfaces further suggests deposition in a meandering stream environment.

Many allochthonous low-terrace gravel deposits are mined at sites where gold enrichment from local sources has also occurred. The latter include mainly Tertiary paleochannel deposits that have been eroded by the modern stream channels. In the Fraser and Quesnel River valleys, for example, deposits of this type occur downstream of the Tertiary mine and in the Big Canyon area (Figure 2, Locations 45 and 48). Gravels mined at the Golden Bench mine on a low terrace of the Cottonwood River (Figure 2, Location 51) are typical of many allochthonous terrace placer deposits in the region. The gravels exhibit well developed stratification, clast roundness, sorting and imbrication. Stratification consists of horizontally bedded gravels with some planar and trough crossbedded units. Trough crosslaminated sand lenses are common and 1 to 2 metres of laminated to massive fine sands typically cap the sequence. Gold occurs in the upper few metres of the gravels. The dominance of small flattened flakes reflects a relatively long distance of transport, typical of allochthonous placer deposits. Gold also occurs at this site in paleochannel gravels resting on bedrock about 20 metres below the terrace surface.

POSTGLACIAL COLLUVIAL AND ALLUVIAL FAN SETTINGS

Productive postglacial colluvial and alluvial fan placers are relatively rare in the Cariboo (Figures 2 and 4, Locations 58 to 61). Colluvial placers are especially rare due to the inefficiency of gravity dominated processes as sorting mechanisms, as compared to fluvial processes. These include slope wash, rilling, gullying, creep, solifluction and other processes that concentrate heavy minerals during downslope movement by either winnowing lighter minerals or by gravity sorting. They are controlled by factors such as slope gradient and aspect, frequency and duration of rainstorms and snowmelt events, frequency of freeze-thaw cycles, vegetation type and density of cover, and thickness and type of surficial material. Slope deposits are typically poorly sorted, poorly stratified and locally derived as indicated by an abundance of angular clasts of local bedrock (Plate 25). Gold concentrations in colluvial placers are generally not economic except where the deposits are spatially associated with well-mineralized bedrock or older placer deposits. The concentration and grain size of gold typically decreases downslope from the source in colluvial and alluvial fan placers (Boyle, 1979; Morison, 1989; Levson and Morison, in press).

An open-pit mine at the mouth of Carberry Creek (Figures 2 and 12, Location 42) provides a good example of a postglacial alluvial fan placer deposit. Crude stratification, poor sorting and large clast size in most beds indicate debris-flow deposition. Beds have a consistent, down-fan apparent dip of at least 5°. The fan sequence coarsens upwards reflecting fan progradation into the valley. Although alluvial

Plate 25. Auriferous, poorly sorted, colluvial deposits on Burns Mountain (Location 41). Local derivation is indicated by the abundance of angular clasts of local bedrock.

fan deposits of this type can usually be readily identified on airphotos by their geomorphic expression, some postglacial fan sediments exhibit little or no fan geomorphology due to the absence of well-developed fan-head channels. These deposits can only be recognized by their sedimentologic characteristics (*see*, for example, Locations 60 and 61, Chapter 5).

Postglacial colluvial and alluvial fan placers are most common in areas where gold was reworked, sometimes in multiple cycles, from previously concentrated fluvial deposits. For example, in the Mount Nelson area (Figures 4 and 7, Location 58), gold recently recovered from surface gravels was probably originally derived from older sub-till gravels that have been hydraulically mined in the past (Johnston and Uglow, 1926). Some of the gold may have been incorporated from the older gravels into the till of overriding glaciers before being subsequently reconcentrated by postglacial alluvial and colluvial processes to form the gold-bearing surface gravels.

Similarly, in the Nelson Creek area (Figures 4, 7 and 34B, Location 61) gold-bearing diamicton and interbedded poorly sorted gravels, interpreted as postglacial alluvial fan deposits, occur downslope from paleogulch gravels that were historically mined in the area. Resedimentation of the older deposits along the valley slope occurred by gravity-dominated processes with minor fluvial reworking. Diamicton beds have characteristics typical of debris-flow deposits including numerous angular clasts of local bedrock with crude imbrication indicating a downslope paleoflow. Interbedded sand and gravel lenses are interpreted as intermittent alluvial channel deposits. Some of the gold in the fan deposits may also have been reworked from tills in which older gold-bearing gravels were incorporated during glaciation. Sedimentation of the fan deposits probably occurred mainly in the period immediately following deglaciation when lack of vegetation and climatic conditions promoted slope instability.

A small operation along Williams Creek (Figures 4 and 7, Location 59) is a good example of a mine recovering gold from a thin colluvial deposit (Figure 34A). The mined deposits directly overlie a bedrock surface that slopes steeply (15° to 20°) toward the valley centre. Poor sorting, chaotic fabrics and numerous angular local clasts in coarse gravel beds are indicative of debris-flow deposits whereas thin interbeds of moderately sorted pebble-gravel beds with more well-rounded clasts and some openwork lenses are interpreted as localized fluvial (rill and small gully) deposits. The most productive units within the sequence are clast-supported, sandy pebble-gravels. As in other deposits of this type, highly auriferous paleostream placers from which gold may have been recycled, occur close to the site. As the deposit occurs above paleochannel gravels in the valley bottom, it is probable that gold was eroded from the rich paleoplacers by glaciers, and redeposited along the valley wall at this site where it was subsequently reconcentrated from the till by postglacial slope processes.

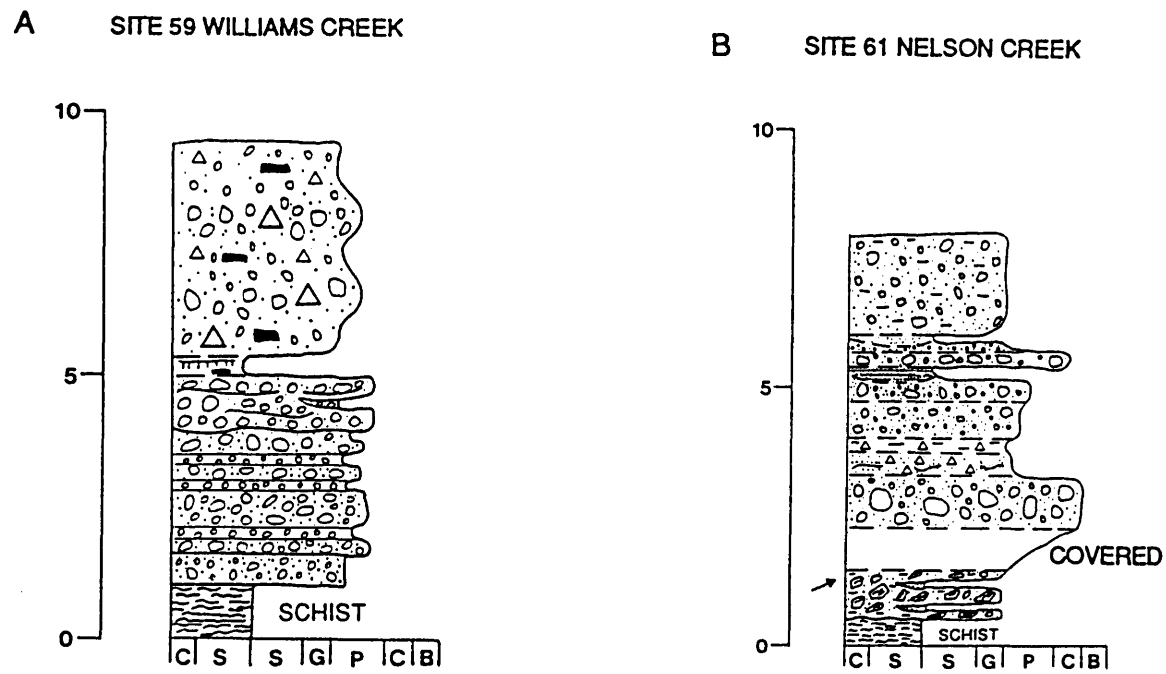


Figure 34. Stratigraphic sections representative of postglacial colluvial and alluvial fan placer deposits. A) Poorly sorted, colluvial gravels and diamicton overlying bedrock along the lower mountain slopes adjacent to Williams Creek (Location 59); B) Gravels and debris-flow diamicton of inferred alluvial fan origin near Nelson Creek (Location 61). *See* Figure 14 for legend. Horizontal scales indicate mean grain size: C-clay, S-sand, Si-silt, G-granule, P-pebble, C-cobble, B-boulder.

CHAPTER 5 ECONOMIC GEOLOGY AND PLACER POTENTIAL

INTRODUCTION

The geology of each site visited in this study is described in this chapter. Property descriptions include information on the stratigraphy, sedimentology and geomorphic setting of auriferous strata as well as data on the nature (size, shape etc.), grade, quantity and distribution of gold where available. Geological interpretations of the gold-bearing zones and overburden sequences are also provided for each property as is a discussion of placer potential.

Sites are organized in this chapter (and in Appendix B of this report) using the geologic classification outlined in Chapters 3 and 4. In many cases, multiple gold-bearing strata occurring in more than one geologic setting are present at the same site. To avoid repetition, all deposit types at these sites are discussed together and they are arranged according to the classification of the most dominant deposit. A good example of this is the Ballarat mine (Location 29) where the gold-bearing strata were deposited in both paleochannel and paleofan/fan-delta settings. However, because the main gold-bearing units occur in the former setting, they are presented here with other paleochannel deposits.

BURIED TERTIARY PLACERS IN THE QUESNEL TROUGH; (Locations 1 to 3)

QUESNEL RIVER - BIG CANYON AREA (Location No. 1, Figure 6)

SITE DESCRIPTION

This site is located along the Quesnel River near Big Canyon, about 3 kilometres east of Quesnel. In 1989, there was a large exploration project (Farrow Mineral Development Corp.) on a high terrace, and a small active mine (Corless mine) on a low terrace, both on the south side of the river (*see* also Location 48). There is at least one inactive mine on a low terrace on the north side of the river upstream from Big Canyon. Tertiary gravels are not mined at this site due to their induration. The locations of measured sections in the area are shown on Figure 15 and a schematic cross-section is presented in Figure 16. A geologic cross-section of preglacial gravels in the Big Canyon area is presented in Figure 35.

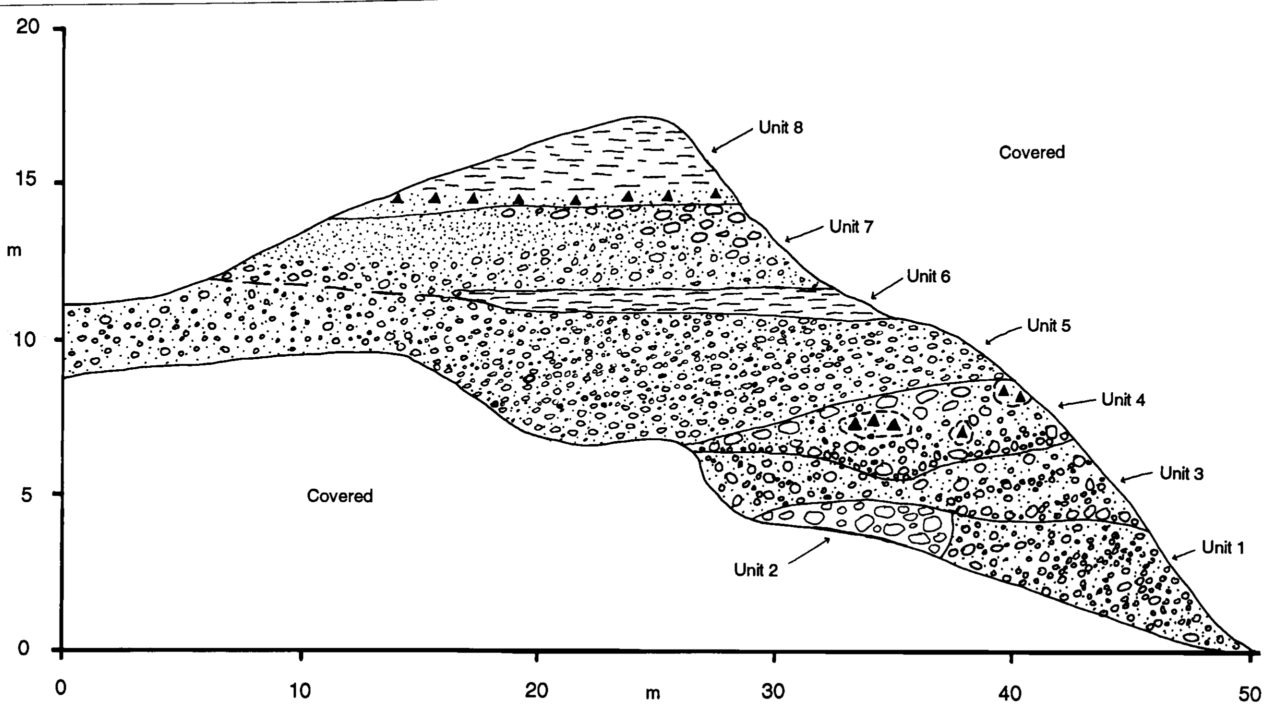


Figure 35. Geologic cross-section of preglacial gravels (Unit 1) in the Big Canyon area (Location L, Figure 15), overlain by interglacial deposits (Units 2 to 4), glaciofluvial gravels (Units 5 and 7) and glaciolacustrine sediments (Units 6 and 8). Gravels in each stratigraphic package are lithologically and sedimentologically distinct. *See* Figure 14 for legend.

Plate 26. Large-scale, low-angle trough crossbeds with interbedded sand lenses in preglacial braided steam deposits exposed along the Quesnel River (Location 1). Exposure is 11 metres high.

Plate 27. Bedded gravels with broad, trough-shaped sand and gravel lenses exposed along Abhau Creek (Location 3), interpreted as Tertiary braided stream deposits of the Fraser Bend Formation.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

Partially cemented, texturally mature, paleochannel gravels occur at the base of a number of exposures in this area (Unit 2, Figure 16; Sections 8901A/B, C/D, I, J and K, Appendix 2). The gravels exhibit horizontal bedding and large-scale trough crossbedding with interbedded trough-shaped sand lenses (Plate 26). They are interpreted as Tertiary or early Pleistocene preglacial deposits of a braided stream. Paleocurrent indicators in these gravels at three different sites (J, AB and H on Figures 15 and 16) generally suggest an east to northeast-flowing system (Figure 17) in contrast to the present Quesnel River which flows northwesterly. Imbrication data from Unit 2 (Figure 16) indicate a shift in the paleoflow direction from the southeast (fabrics A and B, Figure 17) at the base of the unit to the northeast near the top (fabric C). At one site (Location L, Figure 15; see also Section 8901L, Appendix B) the preglacial gravels (Unit 1) are overlain by at least two distinct gravel sequences (Units 2 to 7) that contain a much greater variety of clast lithologies (Appendix C). The top of the lower gravel sequence (Unit 4) locally contains large diamicton intraclasts and is interpreted to be an interglacial gravel. The overlying gravels (Units 5 and 7) are interpreted as glaciofluvial gravels deposited during the advance phase of the Late Wisconsinan glaciation. They grade upwards (Figure 14a) into glaciolacustrine sediments (Unit 8). Late glacial and postglacial terrace gravels (*see* Units 6 to 8, Figure 16) unconformably overlie the older deposits throughout the region.

Gold contents in the basal cemented gravels are probably highest in paleochannel thalwegs on bedrock. Systematic testing of these lower gravel units is required to evaluate their potential. Recovery of gold from the gravels will be difficult due to their cementation, and processing systems probably will need rock crushing components. The thickness of glaciofluvial and glaciolacustrine deposits (Unit 5; Figure 16) overlying the auriferous gravel (*e.g.*, Section 8901M, Appendix 2) probably precludes open-pit mining and large-scale exploitation will require underground workings. Some gold may also occur in stratigraphically higher, interglacial gravels (Unit 3; Figure 16) such as exposed at Section 8901L (Appendix 2).

The best placer potential in the area is in low-terrace gravels (Units 7 and 8, Figure 16), particularly where they overlie older cemented gravel or bedrock (for example, Section 8901E, Appendix 2). Highest gold concentrations occur in lag deposits consisting of large-pebble and cobble gravel, usually at or near the basal unconformity of the Holocene terrace gravel (Plate 10). Large-volume placers with relatively low gold concentrations may also occur in high-terrace gravel in the region (*e.g.*, Unit 6, Section 8901F, G and H, Appendix 2). Care should be taken not to confuse relatively barren, glaciofluvial gravel, such as the surface deposits at Sections F, G and H (Figure 16) with gold-bearing preglacial or Holocene units.

TERTIARY AND ALLSTAR MINES (Location No. 2, Figure 6)

This site is located along the Fraser River about 18 kilometres northwest of Quesnel. At least two underground operations have mined the Tertiary gravel in this area, including the historical Tertiary mine on the east bank and, in recent years, the Allstar mine on the west bank of the Fraser. The property was inactive when visited.

Gravels exposed at this site (Figure 14B) are interpreted to be wandering gravel-bed channel deposits with gold most concentrated in bedrock lows or paleochannels. Underground mining was conducted at the Allstar mine during the 1980s with reported approximate grades as high as 8.5 grams per tonne in the lowermost pay zone. Locating the paleochannel thalwegs is the major geologic problem challenging underground mining operations. Previous mining followed the bedrock surface which generally dips west. Further extraction of the gravel will also require underground mining techniques. Gold recovery is hampered by the degree of cementation of the gravel increasing processing costs.

AHBAU CREEK PROPERTY (Location No. 3, Figure 6)

GEOLOGY

Well-stratified and imbricated pebble gravels are exposed on the south bank of Ahbau Creek (Section 8903, Appendix B) just upstream from its confluence with the Cottonwood River and at nearby roadcuts. Excellent exposures of oxidized gravel of Tertiary age occur along the lower Cottonwood River and Fraser River near their confluence. The gravels are overlain successively by tens of metres of weakly lithified, oxidized silts and clays (Tertiary lacustrine deposits), glaciolacustrine silts and clays and glacial diamicton deposits. Numerous recent exposures have formed as a result of slumping and associated cutbank erosion along both rivers. Recent exploration for Tertiary placers has been conducted in the area.

INTERPRETATION

Gravels exposed along Ahbau Creek and the lower Cottonwood River, exhibiting horizontal bedding with broad, trough-shaped sand and gravel lenses (Plate 27), are interpreted as braided stream deposits of Tertiary age, probably equivalent to the Fraser Bend Formation. They occur in the vicinity of a large north-trending, buried Quaternary valley that approximately parallels the Fraser River valley along its east side. They stratigraphically underlie thick sequences of Tertiary lacustrine and Quaternary glacial, glaciofluvial and glaciolacustrine sediments (Clague, 1988). Miocene rocks of the Fraser Bend Formation, at their type locality on the Fraser River, include a quartz-rich conglomerate 3 metres thick, overlain by 55 metres of weakly cemented gravel and sands, and 90 metres of clay and fine gravel (Rouse and Mathews, 1979). Overlying Tertiary rocks include Middle Miocene diatomite of the Crownite Formation and Late Miocene plateau basalts. Rouse and Mathews interpreted the basal gravel as the product of a large south-flowing river and finer grained beds as floodplain or backswamp deposits.

The basal gravels in the region are commonly auriferous and gravel beds higher up in the formation may also contain gold.

HORSEFLY RIVER AREA (Location No. 4, Figure 6)

This minesite is located on a low terrace on the west bank of the Horsefly River. The deposit was first mined hydraulically and has more recently been worked by underground methods. Figure 14C is a stratigraphic column of the deposits exposed in the vertical highwall remaining from the hydraulic operations. An adit is collared at the base of the section and presumably follows the gravel-bedrock contact towards the west.

Auriferous, texturally mature, Miocene gravels exposed at the base of this section were first mined at the start of the Cariboo gold rush in the 1850s. Grades of approximately 27 grams per tonne (approximately 0.8 oz/ton) at the base to 0.5 gram per tonne (0.015 oz/ton) in the upper part have been reported from gravel in the Horsefly area (Galloway, 1921). The earliest mining at this site was by hydraulicking but gold recovery was inhibited due to induration of the gravel. Gold values of 2.5 grams per tonne were reported when a small stamp-mill was used to process the cemented gravel at the turn of the century (Anonymous, 1903). Historical reports and geologic investigation of the area suggest that a substantial amount of gold-bearing strata may still remain buried. As with Locations 1 and 2, further exploitation of the cemented gravel will require underground hard-rock mining techniques. Previous underground operations have mined the lower part of the cemented gravel as well as some of the bedrock.

PALEOGULCH PLACER DEPOSITS IN HIGH-RELIEF AREAS; Locations 5 to 13 (*See also* Locations 21 and 42)

The placer deposits described here are classified as pre-Late Wisconsinan paleogulch deposits. All occur in steep-gradient paleochannels in mountainous regions with relatively high relief. Eight of the nine sites described are within the Barkerville Terrane in areas underlain by quartzitic rocks of the Downey and Harveys Ridge successions of the Snowshoe Group.

Rucheon Creek (Larsen Gulch) Mine (Location No. 5, Figure 10)

A small mining operation in this area is working poorly sorted, oxidized gravel at the base of a thick succession of sand and gravel. The active mine is at the head of a large hydraulic pit on Rucheon Creek dating from the 1930s, also known as Larsen Gulch. Figure 19A is a composite stratigraphic column of the deposits exposed in the area (Sections 8905A and B, Appendix 2).

Gold-bearing coarse gravels currently being mined (Section 8905A, Appendix 2) are overlain by approximately 20 metres of glaciofluvial sediments capped by a till. They are interpreted as paleogulch deposits left from previous hydraulic operations and may also include, in their upper part, some colluvium slumped into the old pit. Although the mined gravel is auriferous, gold values are expected to increase with depth and proximity to bedrock. Productivity may also increase as the oxidized gravel is mined further upslope and towards the valley sides (where bedrock is presumably closer to the surface). Mining so far has been hindered by water problems and gold recovery is limited by the small size of the operation.

DRY-UP GULCH MINE (Location No. 6, Figure 7)

SITE DESCRIPTION

This mine is located on a small tributary of Chisholm Creek which flows into Lightning Creek. Till in the Chisholm Creek valley is reportedly up to 60 metres deep but pinches out rapidly upslope. The 1990 operation included a geophysical exploration program that targeted bedrock benches on the valley side believed to contain sub-till gold-bearing gravel. Old drifts in the benches are found locally. The operation is developing a high-capacity processing plant including a large, circular, gravity separation system with long metal trays and a central pre-sized slurry feed.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

Poorly sorted gravels exposed along the valley wall in the upper part of Chisholm Creek (Section 8906, Appendix B) are interpreted as colluvial debris-flow and slope-wash deposits as indicated by the presence of numerous angular clasts of locally derived schist, and crude bedding with down-valley dips. Similarly, the angularity and proximal lithologies of the clasts in poorly sorted gravels (Unit 1, Section 9006, Appendix B) overlying bedrock along lower Chisholm Creek suggest that they are debris-flow deposits, possibly along the margin of a bedrock channel in the valley centre. Horizontally laminated sands in Units 2 to 4 may be glaciolacustrine sediments and may also include tailings washed down from the old hydraulic pit located 100 to 200 metres upslope. Sandy diamicton in Unit 5 is interpreted to be the product of colluviation since hydraulic mining ceased and may also include old tailings. Silt and sand of Unit 6 are probably recently deposited fine tailings.

Gravel mined at Section 8906 (Appendix 2) had reported gold values of approximately 0.2 to 0.4 gram per cubic metre. Gold recovery was patchy at Section 9006, the basal 1 to 3 metres (Units 1 to 3) over bedrock yielded about 2 grams per cubic metre. The highest gold recovery was in the poorly sorted, lower gravel beds. These deposits may be laterally associated with better sorted channel-gravel facies in the channel thalweg. The best placer targets in this area, however, are bedrock benches that reportedly occur along the valley side above Chisholm Creek. These benches are likely fluvially-cut (buried terraces or paleochannels) and they may be similar to other benches in the region (*e.g.*, Butcher's Bench) where gold was recovered from gravel underlying glacial deposits and colluvium.

OLALLY CREEK PROPERTY (Location No. 7, Figure 7)

This site is located on the north side of Burns Mountain. A number of shafts have recently been sunk in the area, including two in a narrow, deep gully (about 50 metres wide and 100 metres deep). The gully is discontinuous, consisting of a series of deep depressions separated by debris ridges. Approximately 1500 grams of fine gold were reportedly recovered from sands overlying a graphitic bedrock ledge in the lower metre of a shaft 7 metres deep at this site (H. Lavender, personal communication, 1993). Gravels in the lower parts of the shafts produce high groundwater flows throughout the summer months and dye put in one shaft was reported to appear two days later in Tucker Lake in the valley bottom, the lake having no stream inflow. An esker complex visible on aerial photographs of the region trends north and northeasterly down the northeast slope of Burns Mountain into the Slough Creek valley. A small section exposed along an exploration trench 100 metres long (Section 8907, Appendix B) reveals about 10 metres of crudely bedded pebble to large-cobble gravels. They are locally imbricated and exhibit channel and scour structures indicating a fluvial origin. They are interpreted as glaciofluvial gravels on the basis of their high position on the valley side. Poorly sorted beds, particularly those in the upper part of the sequence, may be colluvial in origin.

Deep depressions and gullies in the area apparently are not entirely a result of recent surface erosion. Some surface depressions have the geomorphic expression of kettle holes and are probably ice-collapse features related to the esker complex in the area. It is possible that the topography prior to the last glaciation may have partially controlled the distribution of stranded blocks of ice during deglaciation. The distribution of the depressions and gullies may be related to possible paleogulch channels targeted by the exploration shafts. Reports of deep gold-bearing gravels with high groundwater flow are consistent with the idea of a buried paleochannel, as are the results of the dye test. It is not known how much original gold-bearing gravel has survived erosion by both glacial ice and subglacial fluvial activity related to deposition of the esker complex.

The proximity and geologic similarity of this property to the highly productive buried placers along the south side of Slough Creek (*see* Burns Creek, Nelson Creek, Point and Ketch pits in Appendix D) suggest that there may be some potential for productive, buried, gulch gravel in this area. The local bedrock is mainly micaceous quartzite with interbedded phyllite belonging to the Harveys Ridge succession of the Snowshoe Group. Olally Creek emerges from a pronounced gully on the northeast side of the slope between Burns and Amador mountains, and then swings to the northwest before continuing downslope to the northeast. It is possible that a buried channel may have continued more directly to the northeast than is the present creek. If present, this paleochannel is probably narrow, with a steep gradient and a trend more or less perpendicular to the slope much like modern gulch channels in the region. The distribution of exposed bedrock along Olally Creek and elsewhere in the area should be mapped in order to constrain the location of possible buried channels. A comparison of the local geology with the old Ketch hydraulic pit (Site 40) is also instructive as it gives an idea of the actual size, shape and orientation of paleochannels in the area and potential overburden thickness.

QUARTZ GULCH HYDRAULIC PIT (Location No. 8, Figure 7)

Quartz Gulch (Plate 28) is located on the southeast side of Antler Creek. It was the site of an old hydraulic operation, referred to as the Gold Run hydraulic pit by Johnston and Uglow (1926). Maps by Johnston and Uglow (1926, p. 81) and Bowman (1895, map 367) show Quartz Gulch in the location of First Chance Creek as shown on modern maps. This mine site is presently inactive. Clasts in tailings piles at the gulch top are mostly angular to subrounded, small cobbles of local lithology. Tailings in the lower parts of the gulch are subrounded to rounded with more erratic lithologies such as diorite, limestone and quartzite. The bedrock in the gulch is phyllite. Approximately 10 metres of diamicton and gravel are exposed along the upper part of the old hydraulic pit walls (Plate 28; Section 9008, Appendix B). Johnston and Uglow (1926) reported on records that indicated the auriferous gravel was from 1 to 5 metres thick, 20 metres wide and contained about 1.5 grams of gold per cubic metre.

Gold from previous operations was probably recovered mainly from gravel overlying bedrock flooring the gulch, particularly in natural riffles created by foliation and bedding in the phyllites. The auriferous gravels were presumably paleogulch deposits buried by glacial sediments equivalent to the sequence of deposits described at Section 9008 (Appendix B). There is little evidence of any major activity since hydraulic mining was discontinued at this site and the extent of unexploited gravel is unknown. Excavation of any basal gravel and the uppermost bedrock in the side and headwalls of the gulch may yield gold. The overburden sequence is the main hindrance to mining and includes, in addition to the 10 metres of surficial deposits currently exposed (Section 9008, Appendix B), another 5 metres of till, 15 metres of glaciofluvial sand and gravel, and 15 metres of glaciolacustrine silt and clay (Johnston and Uglow, 1926).

BEGGS GULCH MINE (Location No. 9, Figure 7)

Mining activities in 1989 and 1990 at Beggs Gulch targeted a buried system that may parallel the modern stream channel which flows through the old, highly productive, hydraulic pit. Adits have been driven in both bedrock and unconsolidated materials in attempts to locate the buried channel. The recent mining operation is located northwest of the modern stream. Mining has proceeded from near the valley bottom at about the 1190-metre level and, in 1989, the mined exposure was located at road level about 50 metres northwest of the present stream. On the southeast side of Beggs Gulch (which flows northeasterly into Antler Creek) a high bedrock wall remains, but to the northwest, rim-rock is poorly exposed. Previous attempts to mine

Plate 28. Site of the abandoned Gold Run hydraulic mine at Quartz Gulch (Location 8). Gold-bearing paleogulch gravels underlie at least 10 metres of glacigenic deposits (exposed at right).

northwest of the creek include a tunnel which extends from the present Beggs Gulch channel into the valley wall and several other tunnels on the northwestern side of the gulch. The recent mining strategy was based on reports of the tunnels which apparently indicate that a buried, auriferous paleochannel does exist.

Most gulch placers in this region were mined from postglacial creek channels but there remains good potential for buried interglacial and preglacial gulch placers. At least one paleogulch channel has been mined in the area. A narrow bedrock-floored channel southeast of Beggs Gulch, at an elevation of about 1220 metres, has been mined for coarse gold with one small plunge pool being particularly lucrative. Bedrock exposed at the base of the channel has been smoothed by water action and tailings from the channel consist of rounded clasts up to large boulder size.

STEVENS GULCH MINE (Location No. 10, Figure 7)

This site is located on the south side of a small creek occupying Stevens Gulch, about 100 metres vertically above the road along Antler Creek. Exposed sections occur within the active mine on the southeast side of the valley wall (*e.g.,* Figure 19B). The mining operation exploits remnant buried-gulch deposits. Gold-bearing, sandy pebble gravels (Unit 2, Section 9010, Appendix B) overlie bedrock and have recently been mined with estimated yields of approximately 10 grams of gold per cubic metre. Nuggets weighing 5 to 15 grams are common. The largest observed was about 60 grams. Most of the coarse nuggets were subangular to rounded with few being well rounded.

Similar remnant gold-bearing gravel and debris-flow deposits may exist elsewhere along Stevens Gulch. Exploration should follow the bedrock contact both upslope and downslope of previously mined areas and closer to the sides of the creek. In addition, the area has potential for undiscovered buried-gulch channels that may be parallel or oblique to the modern Stevens Gulch channel.

CALIFORNIA GULCH MINE (Location No. 11, Figure 7)

This site is located on the south side of a small creek occupying California Gulch, above Antler Creek. The active mine exploits buried gravels on a small (~30 metres high) bench or terrace. A stratigraphic section measured along a vertical highwall at the western end of the mine is represented in Figure 19C. The lowest exposed gravels (Unit 1, Section 8911, Appendix B) are interpreted to be paleogulch deposits. Overlying deposits are interpreted as glaciofluvial delta and associated proximal glaciolacustrine sediments (Units 2 to 4), colluviated till (Unit 5) and late-glacial kame terrace deposits (Units 6 and 7).

Gravel at the base of the section does not directly overlie bedrock. It is presumed that gold content increases with depth and that the highest values will be recovered from gravel in contact with bedrock. This deposit demonstrates that unexploited, buried-channel deposits still exist in the region and also illustrates the thick overburden that typically overlies the paleogulch gravel and inhibits mining.

NUGGET GULCH PROPERTY (Location No. 12, Figure 8)

This site is located on the side of an old hydraulic pit in Nugget Gulch, a small tributary to upper Antler Creek. No current mining activity was observed and only a brief description of exposed deposits at the site is provided (Section 8912, Appendix B). Gold was previously mined from gravel overlying bedrock at the base of the sequence, but auriferous deposits are no longer exposed.

The deposits exposed at this site are believed to be glaciofluvial (Units 1 and 3), glaciolacustrine (Unit 2) and glacial (Unit 4) in origin and contain relatively low quantities of gold compared to stratigraphically older paleogulch gravel that was mined by previous hydraulic operations. As elsewhere in the region, horizontally laminated, fine sands (Unit 2) resulted from ice-damming of the local drainage and the capping till (Unit 4) was deposited as ice over-rode the site during the last glaciation. Future exploitation of placer deposits in the area will have to focus on remnant paleogulch deposits at the head and sides of the hydraulic pit and will be hindered by the thick overburden sequence described below.

BLACK CREEK MINE (Location No. 13, Figure 6)

This mine is located on Black Creek, a small southerly flowing tributary of the Horsefly River, about 25 kilometres east of Horsefly townsite. The mine is at an elevation of about 990 metres on the south flank of Horsefly Mountain. It lies just upstream of a modern canyon, in places about 20 metres wide and 50 metres deep, with several sharp bends.

GEOLOGY

Gold-bearing gulch gravel previously mined at this site most likely resulted from Holocene erosion by Black Creek, probably to the level of glaciolacustrine silts and clays now exposed along the creek at the head of the canyon. More recent operations have targeted older, buried, gulch gravels that stratigraphically underlie the glaciolacustrine deposits and have been intersected in drill holes in the area. Small exposures of the paleogulch deposits reveal massive, fining-up-gravel sequences (Unit 4) Section 9013B, Appendix B) interpreted as channel-fill deposits. They are overlain by 10 metres of glaciolacustrine sediments (Units 5 and 6), 7 metres of glaciofluvial gravels (Units 7 to 15) and 5 metres of till.

Relatively low grade, surficial gravels (Section 9013A, Appendix B) stratigraphically overlying till have also been mined at this site. These deposits contain about 0.05 gram of gold per cubic metre except at the base where large boulders occur and the gold content is significantly higher. They include poorly sorted, crudely stratified gravels with bedding dip directions indicating a westerly paleoflow. The gravels are lithologically diverse and contain some diamicton and mud intraclasts. They are interpreted as retreat phase glaciofluvial gravels deposited when ice in the main valley resulted in the development of an ice-marginal kame terrace occupied by westerly flowing streams. Previously deposited sediments, including diamicton, clay and auriferous gravels, were eroded by these streams as indicated by intraclasts and gold in the gravels. Gold in these gravels occurs mainly downstream (west) from Black Creek gulch in bouldery layers where significant reconcentration has occurred.

PLACER POTENTIAL

The best placer target is a possible south-trending preglacial Black Creek gulch - albeit deeply buried and probably narrow, deep and sinuous, similar to the modern canyon. The possible existence of a west-trending paleochannel was examined in 1973 with a few seismic lines running parallel to the creek on both sides of the valley. The survey indicated an undulatory bedrock contact with a maximum depth of about 20 metres and no conclusive evidence for an east-west paleochannel. The possible existence of south-trending paleochannels was apparently not investigated. According to drill-hole data, the bedrock upstream from the lower Black Creek falls rises abruptly from a depth of about 30 metres to form an exposed bedrock ledge over which the falls drop about 50 metres into a narrow rock-walled canyon. The abrupt change in the bedrock topography above the falls may be explained by a paleochannel oriented obliquely to the modern channel and is a potential placer target. Deltaic gravels (Units 7 to 9 at Section 9013B, Appendix 2) and advance phase ice-marginal channel gravels (Units 10 to 14) may also contain some gold, especially where they contain abundant, angular bedrock clasts (and possibly some older reworked placer channel gravel). In addition to buried deposits, near-surface Holocene and glaciofluvial gravels (such as at Section 9013A, Appendix 2) in the area also have potential to be gold bearing, particularly where they have eroded and reconcentrated gold from older gravel units.

PRE-LATE WISCONSINAN, LARGE PALEOCHANNEL DEPOSITS; (Locations 14 to 31)

ALICE CREEK MINE; (Location No. 14, Figure 11)

This mine is located on the east side of Alice Creek approximately 0.5 kilometre upstream from its confluence with John Boyd Creek, a tributary of the Cottonwood River. The mine is about 3 kilometres northeast of Cottonwood and lies near the eastern margin of the Quesnel Trough. The property was inactive but several good exposures were present due to recent open-pit mining. A composite stratigraphic section is presented in Figure 26A and a location map in Figure 24.

The pay gravels were exposed only in their uppermost part at the time of the property visit (see Unit 1, Section 8914A, Appendix 2). They reportedly are 4 to 8 metres thick, massive, matrix filled and weakly cemented (M. Poschner, personal communication, 1989). Some underground mining of the gravels was undertaken in the late 1980s. Gold values increase toward the base of the gravel with the main pay zone in the lower 3 to 5 metres over bedrock. Pay streaks are sporadic, producing an average of 4 grams per cubic metre with a maximum return of about 9

Plate 29. Dropstones in parallel-laminated silts and clays interpreted as glaciolacustrine sediments at the Alice Creek mine (Location 14).

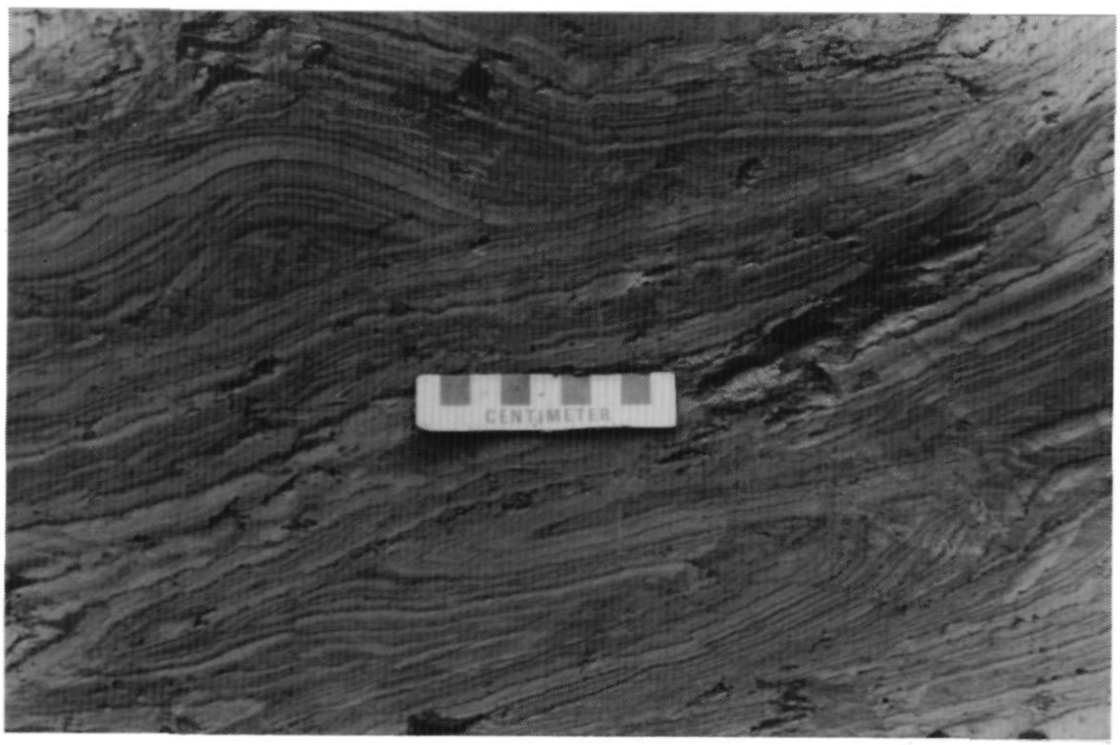


Plate 30. Compressional folds and thrust faults interpreted as glaciotectonic structures that developed in a deforming subglacial bed and possibly inhibited erosion of older gold-bearing gravels in the area (Location 14).

grams. The auriferous gravels are believed to be equivalent to the basal gravels mined nearby at Mary Creek (Location 15, Section 8915F, Appendix 2) and represent paleochannel deposits of probable Tertiary age (Rouse *et al.*, 1990). The gold-bearing gravels are overlain by about 30 metres of overburden (Figure 26A). Massive diamicton units are interpreted as tills. They are separated by intertill sands and gravels probably deposited by a glaciofluvial stream. Laterally extensive silts and clays in Unit 1 are well laminated and contain numerous dropstones (Plate 29). They are interpreted as glacial lake sediments deposited during a temporary retreat of ice from the region during the late Pleistocene. The glaciolacustrine sediments are strongly deformed (Plate 30) and may have acted as a deformable bed under the overriding glaciers that inhibited erosion of the older gold-bearing gravels in the area.

Two holes were drilled at this site in 1992 to investigate the potential of buried river channel deposits in the region (Levson *et al.*, 1993a). The drill sites were selected in order to constrain the paleogeography of the paleochannel system as its extent and orientation are not known. The location of the first hole, due west of the Alice Creek mine, was chosen on the basis of industry drill records (E. Kruchkowski and J. Wyder, personal communication, 1992). These data defined a deep channel in the Alice Creek valley with a cross-sectional geometry suggestive of a west-trending paleochannel. Bedrock was intersected under till at a depth of about 10 metres, well above base level in the Alice Creek paleochannel. This information, together with the known distribution of bedrock outcrops in the area, provides a new constraint on the orientation of the paleochannel system. The results lead to the hypothesis that placer gravels mined on the east side of Alice Creek must have been deposited in a paleochannel system that either extends to the north or swings sharply to the south. To test this, a second hole was drilled about 1 kilometre north of the Alice Creek mine. Several metres of gold-bearing gravels were encountered in this deep hole with bedrock occurring at 36 metres depth. These gravels are believed to be the deposits of a northerly extension, possibly a tributary channel, of the main paleochannel system.

This site provides an excellent example of the mining potential of deeply buried preglacial fluvial placers. The cost of removing large volumes of overburden is offset by the potential richness of the deep gravel. In deposits of this type, detailed sedimentological and stratigraphic data will help identify the extent and volume of gold-bearing strata, as well as the thickness of overlying barren sediments at present mines and in areas of active exploration. Similarity between gold-bearing gravels at this site and the nearby Mary Creek mine (Location 15) suggests that the channel deposits are laterally extensive. Systematic drilling, and possibly also geophysical testing, is required to define the orientation and extent of the auriferous channel deposits. Due to the thick overburden, the gravels will have to be exploited either by underground mining techniques or carefully planned open-pit methods. Careful paleogeographic reconstruction of the channels may also help identify areas where the gold-bearing gravels are less deeply buried and can be easily mined.

TOOP NUGGET MINE (Location No. 15, Figure 11)

SITE DESCRIPTION

This mine is located along Mary Creek, directly upstream from its confluence with Alice Creek. Both creeks flow into John Boyd Creek, a tributary of the Cottonwood River. The mine is directly west of the Spanish thrust (Figure 11) near the eastern margin of the Quesnel Trough. This site is located in a meltwater channel and, unlike the nearby mine at Alice Creek, much of the overburden has been removed naturally by glacial meltwaters. A composite stratigraphic section of exposures at the site is presented in Figure 26B. The location of each measured section is shown in Figure 24 and a correlation diagram is provided in Figure 25. The basal sands and gravels at the site (Units 2 and 3, Figure 25) comprise the main gold-bearing strata (Plate 18; *see* also Section 8915F, Appendix 2). They are overlain by two diamictons (Units 5 and 7, Figure 25), separated by sands and gravels (Unit 6, Figure 25; Figure 26B; Plate 31; *see also* Sections 8915A to D in Appendix B). Discovered in 1972 by Terry Toop, this mine site is noted for its abundance of coarse nugget gold. A discussion of the history of the property has been provided by Barlee (1977).

PLACER POTENTIAL

The main gold-producing strata at this site occur in a buried channel near the confluence of Mary and Norton creeks (Figure 24). The paleochannel trends westerly within the mined area but its extent beyond the property has not been defined. There are several gold-producing stratigraphic horizons in the area. The lowermost auriferous deposits were not observed but they reportedly are poorly sorted gravels containing substantial quantities of clay, probably deposited by mud flows (Roed, 1988). They stratigraphically underlie cemented, auriferous gravels (Plate 18) exposed at the base of Section 8915F (Units 1 to 9, Appendix 2), interpreted as preglacial braided stream deposits. Gold concentrations also occur in intertill sands and gravels (Plate 31) and in the surficial glaciofluvial gravel sequence (Unit 8, Figure 25). The cost of overburden removal to reach the relatively rich basal gravels has been offset by gold production from these postglacial and interstadial gravels.

The best placer potential in the area lies in the buried paleochannel system, although its extent and orientation have not been well defined. Although systematic paleocurrent analyses were not conducted by the miners on the lowermost auriferous gravels before they were removed, some paleoflow data were collected by the authors on the basal, cemented gravels at Section 8915F (Appendix 2 and 3). Paleocurrent data for this and other auriferous stratigraphic units should be combined with structural and geomorphic information from this site and adjacent areas to identify targets for drilling or seismic investigations. The Spanish thrust fault is a major structural feature in the region (Figure 11) and possible geologic relationships between this fault and the occurrence of gold at this site (and others in the area)

Plate 31. Auriferous sands and gravels overlying diamicton interpreted as till at the Toop Nugget mine (Location 15). Till overlying the gold-bearing strata has been removed. Measuring rod is 4 metres long.

should be considered in future exploration activities. In 1992, the property was being reassessed with several options for further exploration identified, including the digging of exploration pits along Mary Creek above its confluence with Norton Creek, farther downstream (west) on Mary Creek near Sections 8915F and 9015H, and on the valley sides and walls to the north of Section 8915G (Appendix 2).

MONTGOMERY CREEK PROPERTY (Location No. 16, Figure 7)

This site is along a bench above the Willow River just east of the mouth of Montgomery Creek. Montgomery Creek follows two old hydraulic pits that were excavated in gravels possibly related to an older channel. Reported gold recovery from a small testing plant at the site is approximately 1 gram per cubic metre in the lower 10 to 12 metres, barren from 12 to 16 metres, about 0.5 gram per cubic metre from 16 to 18 metres, less than 0.1 gram per cubic metre between 17 and 21 metres, and 0.2 to 0.3 gram per cubic metre above 21 metres.

The sand and gravels comprising the bench (Section 8916, Appendix 2) are interpreted to be postglacial, gravelly, braided stream deposits. The high level of the terrace surface relative to the modern stream (more than 25 metres higher) and the coarse grain size and poor sorting of the uppermost deposits suggests a glaciofluvial origin. The gravels above Unit 12 are relatively barren and are almost certainly glaciofluvial deposits. Lower gravel units are of unknown age but may also be glaciofluvial or, less likely, interglacial. Manganese or iron staining and cementation in some beds is related to the permeability of the gravels and probably the result of relatively recent groundwater movement. The glaciofluvial gravels do not represent a good placer target except where they may overlie more auriferous, gravel units. The viability of mining operations exploiting more deeply buried channel gravels in this area may be enhanced by recovery of gold from gravel sequences such as the one described here.

UPPER GROUSE CREEK (Location No. 17, Figure 7)

The valley of upper Grouse Creek is deep and narrow with bedrock exposures along most of its length, although thick sequences of sediment are locally exposed. A buried channel that more or less parallels Grouse Creek, known as the Heron channel, was one of the principal mining areas in the Cariboo in the 1860s (Johnston and Uglow, 1926). Although the area has been heavily explored there is potential for paleochannel remnants, particularly buried tributary systems.

Gold production from Grouse Creek far exceeds the 14 000 grams (Appendix D) reported by Holland (1950) as most mining occurred in the 1860s prior to the start of record keeping in 1874. For example, approximately 1.3 million grams of gold was reportedly recovered by the Heron Company from a 120-metre length of the buried-channel deposits having gold concentrations up to 2500 grams per cubic metre, possibly the richest ground in the Cariboo (Johnston and Uglow, 1926). Because the paleochannel gradient is steeper than the modern stream, gold was mined from gravels on high bedrock benches on the upstream reach and from gravels buried below creek level on the lower reach, the transition occurring just above the Heron claim about 1.5 kilometres downstream of Shy Robin Gulch (Bowman, 1895, map 367). Interglacial or preglacial gravel units are the best targets for further exploration in the area, particularly buried, tributary-channel deposits that may underlie valley-fill sequences such as the one described below.

LITTLE SWIFT RIVER MINE (Location No. 18, Figure 6)

SITE DESCRIPTION

This site is located along the Little Swift River about 2 kilometres north of its confluence with the Swift River. Gold-bearing gravels underlying a thick overburden sequence are exposed on the south side of the creek (Section 9018B, Appendix 2). They have been mined from a small bedrock terrace of the Little Swift River that occurs at the intersection of the modern creek and the buried channel.

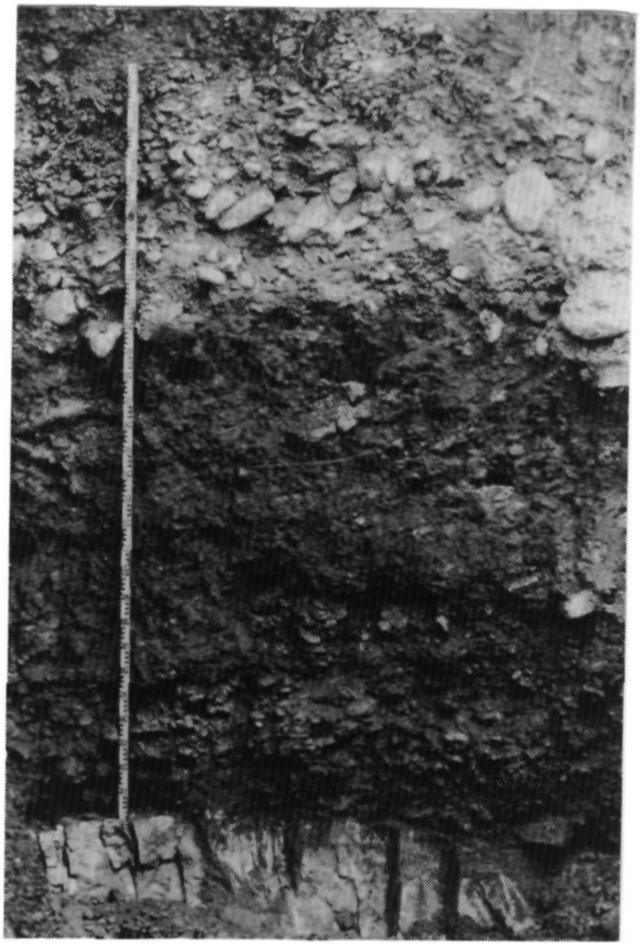


Plate 32. Horizontally bedded, gold-bearing terrace gravels overlying bedrock along the Little Swift River (Location 18), containing approximately 0.2 gram per cubic metre of mainly fine-grained gold. Measuring rod is 3 metres long.

Recent mining has focused on low-terrace gravels (Plate 32), such as those exposed at Section 9018A (Appendix B), occurring downstream from the point where the Little Swift River has cut into the buried channel. At Section 9018A, the basal gravels have a reported gold content of approximately 0.2 gram per cubic metre, mainly fine-grained gold.

Gravels at the base of Section 9018B (Plate 33) were mined in previous years and yielded approximately 0.7 gram per cubic metre, although values up to about 5 grams per cubic metre are reported in localized units overlying bedrock. Coarse gold was common. Mining was focused on a low terrace where the Little Swift River had eroded through the underlying older gravels and presumably reconcentrated gold from those gravels. The mined terrace is approximately 200 metres long by 100 metres wide. Bedrock is no longer exposed in the pit but is reported to be about 10 metres below the base of Section 9018B. Only the upper part of the pay gravels is exposed. The best pay was encountered closest to the bedrock and values decreased upwards through the overlying gravel.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

The sand and gravel sequence exposed at Section 9018A (Appendix 2) is interpreted as a postglacial fluvial deposit (Plate 32). Gold in this terrace was probably eroded and redeposited by the Little Swift River from the older channel gravels occurring about 0.5 kilometre upstream. The relatively low grades and small grain size of the gold at Section 9018A compared to at Section 9018B presumably reflects downstream dilution and comminution.

The lowest exposed units at Section 9018B (Units 1 to 5, Appendix 2) are oxidized, crudely stratified sands and gravels (Plate 33), interpreted as braided stream deposits of

Plate 33. Oxidized, gold-bearing, early Pleistocene or Tertiary, braided stream gravels (lower dark unit) at the Little Swift River mine site (Location 18). The overburden consists of approximately 25 metres of glaciofluvial gravels (light unit, centre), till and glaciolacustrine sediments (mostly covered). Mining concentrated on the terrace in the foreground where the postglacial Little Swift River eroded and reconcentrated gold from the older gravels. Man at right for scale.

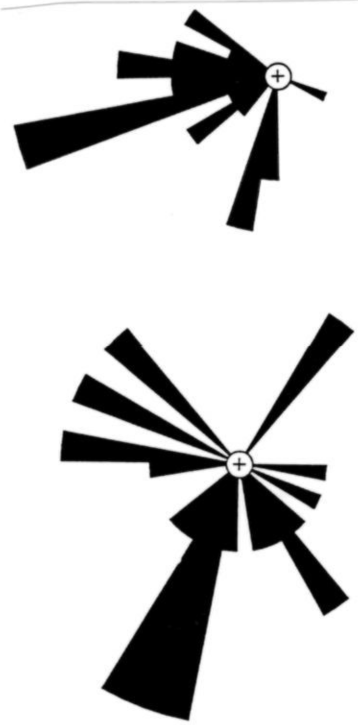


Figure 36. Rose diagrams (of imbrication data) illustrating paleoflow in buried, braided stream gravels of probable early Pleistocene or Tertiary age at the Little Swift River mine (Location 18). The data indicate a dominantly southwesterly paleoflow. Imbrication is better defined in horizontally stratified beds (A) than in massive gravel beds (B).

an old channel. Pebble fabric analyses indicate a dominantly southwesterly paleoflow (Figure 36). Fabric A is from moderately well sorted, horizontally bedded gravels and fabric B is from poorly sorted, massive gravels (Units 2 and 4, respectively, Section 9018B, Appendix 2). Well-developed imbrication, especially in the former, is indicative of traction deposition in horizontally bedded, longitudinal bar deposits. As the gravels underlie till, they predate the last glaciation in the area and are probably early Pleistocene or Tertiary in age. Downcutting by the Little Swift River during the Holocene eroded through the old channel sediments and reconcentrated the gold. A continuation of this auriferous channel may be located south of the mined area, but is probably deeply buried. Gold may also be more dispersed than in the mined area.

Two holes were drilled between the Little Swift River and the Fontaine Creek valley in 1992, about 2 kilometres northwest of this site, to test the potential for a large buried 'trunk' valley trending northwesterly parallel to the Reddish Creek valley (Levson *et al.*, 1993a). Past mining strategies in the region have targeted southwesterly flowing streams such as the Little Swift River and Fontaine Creek, but little attention has been paid to the possibility of a northwesterly trending paleochannel, possibly following the strike of the Eureka thrust (Figure 6). This fault separates the Barkerville and Quesnel terranes and may have provided a major structural control on preglacial drainage patterns in the area. One hole was drilled southeast of the Fontaine Creek valley and intersected gold-bearing gravels of similar thickness and type to those currently being mined in that valley. A second hole was drilled about half-way between the Little Swift River and Fontaine Creek. The occurrence of auriferous gravels at the bottom of this hole provides new evidence that strongly supports the hypothesis that a large northwesterly trending paleovalley does exist in this area.

MOREHEAD CREEK MINE (Location No. 19, Figure 12)

Morehead Creek flows in a narrow valley that drains several linear lakes located along the locally named Morehead channel. Gold production from Morehead Creek was first recorded in the early 1900s (Holland, 1950) but the area continues to be the focus of some mining activity. The original source of gold in the area may have been a buried channel system with the main auriferous deposits occurring stratigraphically below a thick valley-fill sequence (Plate 34). Pay gravel under this thick succession of deposits has

Plate 34. Thick succession of fluvial, lacustrine, glaciofluvial and glacial deposits exposed along Morehead Creek (Location 19). The entire sequence stratigraphically overlies mined auriferous gravels and underlies a Late Wisconsinan till. Man at lower right for scale.

been mined hydraulically in the past and using heavy equipment in recent years. No till-like deposits were exposed at the site but the entire sequence stratigraphically underlies till (located farther upslope). The setting is similar to the Bullion mine in that deeply buried paleochannel gravels predating the last glaciation are overlain by fluvial, lacustrine, glaciofluvial and glacial deposits (*see* Section 8919, Appendix 2). Mining in the area apparently has focused mainly on deposits of the modern Morehead Creek channel. Older, buried gravel deposits in the area also have good potential and should be evaluated.

BULLION MINE (Location No. 20, Figure 12)

The Bullion mine is one of the best known placer gold mines in the Cariboo. It is located about 5 kilometres west of Likely in an old channel of the Quesnel River. The valley is bedrock walled and about 1 kilometre long and over 100 metres deep. It is truncated at the north end by the Quesnel River. The mine pit is about 50 to 100 metres wide at the base and 300 to 500 metres wide at the top. Nine million cubic metres of material were removed from the Bullion channel between 1898 and 1904 after which the mine closed. It was subsequently intermittently active until a large operation began in 1933 and continued until 1942. At this time most material was removed by hydraulic operations supplied by a complex water system that included as many as eight lakes and over 65 kilometres of ditches. A sluiceway 850 metres long extended for nearly 500 metres through a bedrock tunnel from the centre of the mine to the Quesnel River. A detailed description of the mine during this period was given by Sharpe (1939).

Gold in a gravel bar on the Quesnel River led to the discovery of the deposit in 1884. The site was first worked along a small creek that had eroded through, and reconcentrated gold from, the old channel deposits. From 1884 to 1893 about 1650 kilograms (53 000 oz) of gold were recovered and between 1894 and 1905 an additional 2250 kilograms (72 500 oz). Approximately 775 kilograms (25 000 oz) were recovered in the 1930s. Gold was won mainly from the lowermost gravels on bedrock. Recent operations have mined remnant gravels, particularly at the south end of the mine and values up to about 1.5 grams per cubic metre are reported. A 300-gram (10 oz) nugget was found in 1988.

The geology of the Bullion mine was described by Clague *et al.* (1990). Summary descriptions of the section are given by Levson and Giles (1991). Sediments from two glacial periods (tills and glaciofluvial sand and gravel) and intervening nonglacial deposits are locally preserved in the mine area (Figure 22). The main gold-bearing gravels overlie bedrock but some gold also occurs in higher gravel units, probably overlying clay-rich till or old lake deposits that acted as false bedrock.

There is a good probability that other buried-channel deposits related to the same fluvial system as the Bullion mine deposits may occur in the Quesnel River drainage system. For example, Clague (1987b) identified a buried channel similar to the Bullion channel, along the Quesnel River north of Spanish Mountain, as a possible placer exploration target. Gold-bearing abandoned channel gravels are typically overlain by a thick succession of Pleistocene tills and other sediments. Gold occurring within interstadial or postglacial sand and gravel units in the overburden sequence, as well as the potentially high grade of preglacial units, can help compensate for overburden removal costs. In some areas these placers may be economically mined by underground methods and possibly by *in situ* leaching. Detailed geologic data are required to determine overburden depths and to identify the extent and volume of gold-bearing strata in buried placers of this type.

SPANISH MOUNTAIN McKEOWN MINE (Location No. 21, Figure 12)

SITE DESCRIPTION

This property is located on the northwest side of Spanish Mountain about 8 kilometres east of Likely. The gold-bearing gravels appear to fill the upper part of an elevated, steep sided paleochannel eroded in bedrock. The mine is in a north-trending buried valley according to drill and seismic records and excavations. Bedrock rims rise up on both sides of the mine and are covered only by till. The orientation of the channel appears to be oblique to the regional northwesterly strike of bedrock and topography. Drilling results indicate that the bedrock channel is up to 74 metres deep and that the lower 50 metres of the channel is filled with clean, pebble and boulder gravels. The lower gravels have not been mined extensively.

The area was first staked by John Lyne in 1927 and production occurred from 1927 to 1938 by sluicing in Lyne, Oliver and Hurley gulches. Some tunnelling was also undertaken. Mechanized mining began in 1981 and the owners have operated the mine every season since then. Material is bulldozed and loaded by backhoe onto a conveyor to the processing plant where the gravels are washed across a grizzly and screened into separate fractions. The coarser fractions are sluiced and the finer portion is jigged. Fording Coal Limited conducted a large mining operation at the site in the late 1980s, utilizing numerous pieces of heavy equipment and a complex, conveyor and processing system.

Gold content is generally consistent throughout the mined sequence, averaging about 1 gram per cubic metre, not including gold finer than 100 mesh (0.149 millimetre). In the lower gravel zone, gold concentrations are higher closer to the bedrock which is approximately 60 to 80 metres below surface. The gold is both fine and coarse; nuggets up to 185 grams (6 oz) have been recovered. They are often associated with quartz and tend to be rough surfaced and chunky; flattened or flaky gold is rare (McKeown and McKeown, 1989).

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

Gold at this mine is found in both poorly sorted and crudely stratified, compact, silty, coarse gravel, interpreted as debris-flow deposits, and in interbedded lenses of better sorted gravel, sand and silt, interpreted as intermittent fluvial deposits (Sections 8921A and B, Appendix 2). The sedimentology of this gold-bearing sequence is suggestive of an alluvial fan depositional environment. It occurs to a depth of approximately 27 metres and is overlain by poorly exposed diamicton interpreted as till and glacially derived debris-flow deposits, suggesting that the placer deposits predate the last glaciation in the area. The glacial diamicton is thin, poorly exposed or removed by mining activity at most sections but a detailed description was obtained at Section 8921D (Unit 2, Appendix 2). At Section 9021 (Appendix 2) the diamicton thickness is variable and it is irregularly interbedded with the underlying alluvial sediments as a result of colluvial processes.

Gravelly units directly underlying the upper diamicton may be in part glacial in origin. The boulder gravels exposed in Lyne Gulch (Section 8921C, Appendix 2), for example, are non-auriferous and the large size and high angularity of clasts suggests a very high energy, proximal depositional environment. The addition of glacial meltwater and debris into the gulch channel may have allowed for aggradation of these coarse, barren deposits.

Gravels below the mined alluvial fan deposits are well sorted with little silt and are interpreted as fluvial gravel of interglacial or possibly preglacial age. The substantial thickness of these deposits indicated by drilling (>50 metres) indicates the presence of a relatively large paleochannel.

This area has excellent potential, both for continued open-pit mining of the alluvial fan sediments and for possible exploitation of the deeper paleochannel gravel. There is also potential for discovery of other paleochannel deposits in the region, including probable tributary channels to the main system. In addition, buried paleofan deposits may also occur in the surrounding area and elsewhere in the Cariboo in analogous geologic settings, particularly in valley-side locations protected from glacial erosion by bedrock highs.

FOUR MILE CREEK (KEITHLEY CREEK) MINE (Location No. 22, Figure 9)

SITE DESCRIPTION

This property is located along a buried paleochannel that roughly parallels Keithley Creek. The distribution of bedrock exposures suggests that the channel trends at about 150°. The present operation is located at the head of an old hydraulic pit (Engineers pit) near the mouth of Four Mile Creek. There are old sluices and wingdam structures in the base of the pit and some gold has been recovered by underground mining in the past. It is believed that the old channel was not completely worked due to a loss of gradient for sluicing. Thick overburden and lack of water further impeded mining. The current operation is removing material down to the bedrock surface at the base of the old channel, with the mine expanding up into the headwall of the old hydraulic pit (Plate 35).

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

The distribution of bedrock exposures at this mine site suggests the presence of an old canyon-like channel now filled with a thick sequence of fluvial and glacial sediments. Well-stratified sands and gravels (Units 1 to 10) at Section 9022A (Appendix 2) are interpreted as fluvial sediments deposited during an aggradational phase in the old channel. They are overlain by a deformed bed of glaciolacustrine silt and clay (Unit 11) and a thick deposit of stratified glaciofluvial gravel (Unit 12). The top part of the sequence is a poorly exposed package of glacial, glaciofluvial and glaciolacustrine sediments (Unit 13). At Section 9022B (Appendix 2), coarse gravel (Unit 2) overlying bedrock (Unit 1) may be tailings of the old hydraulic pit or slumped fluvial gravel from the original channel.

The potential for the discovery of unexploited paleochannel gravels at this site is good, given that the old hydraulic mine ceased operating due to technical problems. An upstream continuation of the gravels in this setting seems likely and some tributary channel deposits may also exist. There is also no reason to suspect that the channel gravels were eroded by glaciers as till does not occur anywhere in the lower part of the sequence. The thick overburden (45 metres or more) obviously will be a major obstacle to con-

Plate 35. Thick glacigenic overburden overlying buried paleochannel deposits near Keithley Creek (Location 22). The current operation is mining paleochannel gravels along the bedrock surface at the base of the old channel.

tinued mining of the paleochannel gravels by open-pit methods.

STREICEK MINE (Location No. 23, Figure 7)

This property is located on a high bench at the confluence of the Devil's Lake Creek and Slough Creek valleys (Plate 16). A stratigraphic column of the mined deposits is given in Figure 20. Gold occurs in all units below the uppermost diamictons and gold values generally increase with depth. Observed nuggets were up to 28 grams in weight and relatively rounded with smooth surfaces.

The southeast wall of a small paleochannel has been exposed to a depth of 24 metres (Plate 36). The lowest exposed gold-bearing deposit is well-rounded to subrounded boulder gravel grading up into cobble to pebble gravel (Figure 20). The uppermost part of the gravel sequence was deposited as the channel was infilled prior to the last glaciation. This gravel is crudely stratified, poorly sorted and contains an abundant silt and fine sand matrix. The capping diamictons are interpreted as till and glacially derived debris-flows deposited by the Late Wisconsinan glaciers that over-rode and buried the paleochannel.

There is potential for other buried-channel placer deposits in this area, both in the immediate vicinity of the mine and in the surrounding region. Mine excavations and tunnels to the east of the present mine, closer to Devil's Canyon, revealed deposits that are reportedly similar to the basal gravels at Section 9023 (Appendix 2). They were probably also deposited in a confined stream channel. It is not known if these paleochannels were contemporaneous or possibly even connected at one time. The channel profiles are irregular and suggest the presence of small paleowaterfalls and plunge pools. In addition, glacial erosion appears to have locally truncated the channels making paleogeographic reconstructions difficult. Channels of this type are similar to those located on upper Burns Creek and upper Nelson Creek and they may also be found elsewhere in the region, such as along the sides of Amador, Burns, Nelson and Dragon mountains.

GALLERY RESOURCES LIMITED, HANNANDOR PROPERTY (Location No. 24, Figure 11)

SITE DESCRIPTION

This site is located on the south side of the Lightning Creek valley. The entire surficial layer above bedrock is exposed at this minesite. Figure 28 is a composite stratigraphic column of three exposures: Section 9024A at the base, Section 9024B in the middle, and Section 9024C at the top (Appendix 2).

The operation is exploiting gravel unconformably overlying bedrock in a presumed paleochannel of Lightning Creek. The gold-bearing gravel is overlain by a thick (more than 25 metres) succession of overburden gravel with relatively low gold contents. Gravels on bedrock have yielded up to approximately 75 grams of gold per cubic metre but estimates of average gold grade for the entire gravel se-

Plate 36. Crudely stratified, poorly sorted gravels overlying bedrock along the southeast wall of a small paleochannel at the Streicek mine (Location 23). Gravel units are dominated by angular clasts of local shale that dip steeply (up to 45°) into the channel centre due to down-slope movement of sediment during channel infilling.

quence, from the surface to bedrock, vary from about 0.4 to 1.0 gram per cubic metre (Ikona and Darney, 1992). Gold particles are mainly well-flattened flakes less than 5 millimetres in diameter and up to about 2 grams. Fine to medium sand-sized particles are common.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

Gold-bearing gravel is exposed along the northern side of the channel where the bedrock surface slopes 12° to the south (185°). A basal unit consists of interbedded sand and well-sorted, medium to large-pebble gravel (Figure 28). Paleoflow was to the west, similar to modern Lighting Creek channel which lies on the opposite side of the valley. The lowermost gravels are overlain by poorly sorted, very crudely stratified, clast-supported gravel with low quantities of fines in a sandy matrix, typical of sediment-rich, high discharge flood-flow deposits. Interbedded, fining-upward units of moderately sorted and stratified, coarse channel gravels are interpreted as normal stream flow deposits. The overlying gravels and sands, exposed at Sections 9024B and 9024C (Appendix 2), are interpreted as glaciofluvial, braided stream deposits. They are generally moderately to well sorted, subrounded to well rounded, pebble gravel. Well-developed imbrication and stratification indicate fluvial deposition. Near the south valley wall, glacial diamicton (till) locally overlies the glaciofluvial sequence but there is no evidence of till in exposures closer to the valley centre, suggesting that either ice advanced and retreated over the site without deposition or the glacial deposits were eroded by fluvial activity. The latter is more likely as the top of the glaciofluvial deposit is channellized and several erosional unconformities also occur within the sequence.

As bedrock at the base of the section slopes to the south, the paleochannel deposits must thicken in that direction. This suggests that the deepest part of the channel occurs beyond (south of) the exposed sequence and the potential for further exploitation of the buried deposits there is good. The results of a recent drilling program on the property have confirmed the presence of a buried auriferous paleochannel south of the valley (Ikona and Darney, 1992; Levson *et al.*, 1993a). Exploration for the up-channel and down-channel extensions of the deposit, as well as tributary-valley deposits, may also be productive. The relationships of gold production at this site to the Spanish and Eureka thrust faults (Figure 11) should also be investigated, particularly in respect to their potential as source areas. This investigation should include detailed comparisons of gold composition, nugget size and nugget shape between a number of sites along Lightning Creek downstream from the faults.

LIGHTNING CREEK, MCGUIRE PROPERTY
(Location No. 25, Figure 11)

This site is located along Lightning Creek on the south side of the valley. The property was inactive in 1989 but activity in recent years is indicated by several open pits on a low terrace above Lightning Creek. Approximately 2 metres of horizontally bedded medium to large-pebble gravels were exposed under 2 to 3 metres of horizontally laminated sand but the remaining mined sediments were below water level. The local bedrock is shale. Vertical to steeply dipping (70° to 90°) beds striking at 070° act as a natural placer trap. Medium-pebble gravel that accumulated in lows between bedding planes has been mined by hand. The upper bedrock surfaces are mostly smooth and water worn.

Horizontally laminated clay, silt and fine sand in Units 1 and 2 (Section 8925, Appendix 2) are interpreted as glaciolacustrine sediments and the overlying diamicton is probably a till that slumped down the valley wall. The gold-bearing gravels mined at the site include both Holocene terrace gravels and possibly also buried-channel gravels that stratigraphically underlie the till and glacial lake sediments.

Further exploration in the region should concentrate on defining the bedrock topography in order to determine the location of possible paleochannels. Terrace gravel both upstream and downstream from this site may also have potential. Because the auriferous units occur below the water table, the area may be suitable for dredging operations.

WINGDAM
(Location No. 26, Figure 11)

This site has been the focus of several attempts to exploit deeply buried auriferous gravels. The gravels are 2 to 5 metres thick and unconformably overlie bedrock. The gold-bearing zone is believed to be one of the richest paleoplacer deposits in the Cariboo. The gravels are overlain by approximately 25 to 35 metres of clay-rich glacial sediments. These deposits, referred to as 'slum' by early miners, have been the main cause of mine failures and abandonment in the past. They are believed to be glaciolacustrine in origin. The uppermost part of the overburden sequence consists of approximately 6 metres of Holocene gravels. Successful underground mining of gravels that occur above the level of the lowest paleochannel gravels, on an intermediate bedrock bench known as the Sanderson bench, has been conducted just upstream from this site and has accounted for most of the placer gold production from this area (Appendix D). Past attempts at mining the lower paleochannel gravels have failed due to groundwater problems and slumping of the glacial deposits into the mine workings. However, enough of the gravels have been mined to indicate grades as high as 30 grams per cubic metre.

Gold Ridge Resources Inc. began an underground mining operation at the Wingdam property in the winter of 1990-91. The site was drilled over the winter and more holes were planned to delineate the main pay channel. The company completed dewatering of the buried aquifer and sunk a mining shaft through bedrock to a level below the auriferous gravels. Recharge to the buried gravel system is about 20 litres per second and initial dewatering required pumping at a rate of 200 litres per second. Metals are removed from the aquifer groundwater before discharging into the creek. As this is the first successful dewatering program at this site and modern mining technologies are being used, the project is considered to have good potential.

The gold-bearing strata at this property, at one time, must have been part of an extensive buried paleochannel system. If the source of placer gold is related to the Eureka thrust fault, then the down-flow extension of the paleochannel has the best potential, although gold concentrations probably decrease with distance downflow. Although the gold-bearing gravels are separated from the modern Lightning Creek channel by a thick glacial sequence, they form a permeable aquifer in which high water flows have created a significant obstacle to underground mining. For this reason, the potential of this site for an *in situ* cyanide leaching system for recovering gold from the gravels was investigated but abandoned due to environmental concerns. As the auriferous zone is saturated the site may also have potential for *in situ* bioleaching.

EIGHT MILE LAKE (Location No. 27, Figure 7)

The Eight Mile Lake property was the focus of a large operation in the winter of 1988-89 but was mainly in a reclamation phase by the summer of 1989 when visited. Paleochannel gravels below the lake were the target of the operation. The lake was drained during mining but major problems with lake-bottom sediments and organics were apparently encountered. A successful suction-dredging operation was conducted at this site prior to the more recent attempt at open-pit mining (H. Myers, personal communication, 1992). The Thistle hydraulic mine at the southwest end of the lake, worked in the early 1900s, produced more than 600 000 grams of gold (20 000 oz) from approximately 275 000 cubic metres of ground.

Eight Mile Lake is one of the few areas in the Cariboo where a placer deposit has been documented between two till units and, therefore, is clearly interglacial or interstadial (Johnston and Uglow, 1926). The gold was concentrated in a bouldery unit between two diamictons interpreted as tills. The lower diamicton was partially cemented and acted as false bedrock. It was underlain by limestone bedrock and overlain by poorly stratified glacial gravel, silt and an upper diamicton. The lower diamicton contained erratic clasts and was believed to have been deposited by a northeastward-flowing glacier that had incorporated gold from an older bedrock channel (Johnston and Uglow, 1926). Recovered gold was flattened and worn with nuggets up to approximately 20 grams. The channel was only mined above lake level and was believed to extend below the lake (Johnston and Uglow, 1926).

In addition to buried paleochannel deposits in the Eight Mile Lake valley, there is potential for the discovery of auriferous gravels in buried tributary channels. The original hydraulic mine at the site exploited a tributary channel draining the slope south of Eight Mile Lake. The Pleasant Valley thrust lies just to the southwest of the lake and, together with related structures, may control the distribution of gold in source rocks in the area.

SUMMIT CREEK PROPERTY (Location No. 28, Figure 7)

Recent activity at this site has targeted some small buried bedrock channels. There are several open pits in the area but no good exposures. Based on observations of exposed bedrock and the size of the open pits, possible channels are approximately 50 metres wide and 20 metres or more deep. The depth of the channels and groundwater have hampered mining. A large, partially complete dredge, intended for use on the property, was present at the site at the time of the property visit. Large rounded boulders have been excavated from some of the open pits. Auriferous gravels on false bedrock and cemented gravels have been reported.

The presence of large rounded boulders in narrow bedrock gullies at this site suggest that the potential for the discovery of paleochannel deposits is good but the gold content of the buried gravels is unknown. It is probable that buried channels in the area are auriferous and related to the gold-bearing deposits in the Eight Mile Lake area. Gold in the Summit Creek paleosystem may have been derived from the latter area, if the general flow direction was similar to that of the modern drainage. Boreholes in the vicinity of the confluence of Pine and Summit creeks indicate depths to bedrock are locally as high as 30 metres, although 20 metres or less is typical. Systematic drilling in this area will be required to locate and evaluate these potential paleochannel deposits.

BALLARAT MINE (Location No. 29, Figure 7)

SITE DESCRIPTION

The Ballarat mine is located directly east of the Barkerville airfield about 400 metres northeast of Williams Creek. The property lies at the east end of a small pass that is occupied by Weldon Lake and joins Williams Creek and Pleasant Valley Creek. Williams Creek produced at least 1450 kilograms (47 000 ounces) of gold in the 10-year period from 1874 to 1885 (Holland, 1950) and is one of the richest gold-producing streams in British Columbia. The gold-bearing strata at the Ballarat mine underlie 2 to 8 metres of till deposits and fill an ancient bedrock channel. Gold is almost entirely finer than very coarse sand and has a fineness of about 840. The deepest and presumably the richest gravels were not exposed in October 1989 and are as yet unmined.

The sequence of deposits described here stratigraphically overlies the paleochannel deposits described above. They outcrop along a mine highwall on the east side of the property. A north-south cross-section of the exposure illustrating the major stratigraphic units is provided in Figure 30 and the locations of sections A to F (Appendix 2) are shown. A detailed description of the geology of this site was provided by Levson *et al.* (1990) and is summarized below.

DESCRIPTION OF DEPOSITS

Unit 1: Bedrock (Unit 1) is exposed at the northern and southern ends of the main highwall at the Ballarat mine (Figure 30). At the south end it consists of strongly altered muscovite-talc schist and phyllite with quartzite beds 1 to 10 centimetres thick. The schist is crosscut by several discordant quartz veins generally less than 1 centimetre wide. Bedrock exposures at the north end of the mine site are interbedded limestone, bedded quartzites, schist and phyllite.

Unit 2: Discontinuous, thin (<3 metres), diamicton beds (Unit 2, Figure 30) overlie bedrock highs along the sides of the mine. They are matrix to clast supported with 50 to 80% clasts. Locally derived angular schist, phyllite, quartzite and limestone dominate, but some subrounded to rounded pebbles are also present. The matrix is a sandy silt and contains abundant comminuted local bedrock material, in places consisting entirely of brecciated schist or vein quartz. The diamictons have a crude sub-horizontal stratification defined by tabular clasts, locally occurring in boudinaged and folded beds, and thin (<10 centimetres), tabular to trough-shaped, lenses of fine sand and silt. The sands are well sorted and have horizontal to wavy laminations.

Unit 3: The lowest exposed gravels (Figure 27) in the Ballarat pit are moderately sorted, clast-supported, very compact pebbly gravels generally with a fine to medium sand matrix. Some beds exhibit planar and channel-fill crossbedding, and scoured lower contacts (<50 centimetres deep and 2 to 5 metres wide). These gravels generally dip 5° to the south and, in the centre of the minesite, they are unconformably overlain by large-cobble to boulder gravels (Unit 6). Seismic results indicate that approximately 10 metres of gravel are present below these gravels. Gold concentrations are up to approximately 2 grams per cubic metre in this unit and, in general, gold values increase with depth (A. Ball, personal communication,1989).

Unit 4: A complex unit of sand and gravel is exposed at the base of the east highwall along most of its length (Unit 4, Figure 30). Lithologically, these gravels are composed almost entirely of locally derived rocks. At Section E (Figure 30), beds dip 25° to the north and consist of cross-stratified sandy beds grading upward into parallel-laminated silts and poorly sorted, massive to crudely stratified, gravel beds up to 3 metres thick. Convoluted bedding, normal faults, and load and flame structures are common. In the centre of the exposure (Section D) the steep, northerly dip of beds decreases down dip. Sandy beds are laterally traceable for several metres and exhibit wavy parallel laminae, minor trough crosslaminae, low-angle climbing ripples and angular inclusions of sandy gravel. Bed contacts are sharp and conformable although lower contacts are locally scoured or marked by injection structures or intraclasts. Gravel beds generally pinch out down-dip or are eroded by overlying strata. Some gravel beds grade up-dip into the overlying gravel unit. At Section C coarse sand and pebble gravel beds occur in a deformed unit with a generalized trough shape (Figure 30). Gravel beds are poorly sorted, chaotic and locally grade into pebbly sands. The intensity of deformation increases to the north where the deformed zone is bounded by a steeply dipping lens of massive to poorly laminated silt and fine sand (Figure 30). Beds south of the silt lens are reverse faulted, folded and dip up to 35° to the south. The silt lens is folded, branched, locally boudinaged and characterized by soft-sediment deformation structures. At Section A (Figure 30) this unit consists mainly of poorly sorted gravel with no apparent stratification, except for some cobble and boulder clusters and a crudely stratified, trough-shaped lens of cobble gravel fining upward into coarse sand in the upper part of the unit. In places the gravels grade into matrix-supported silty diamicton with clasts that are commonly angular, of local origin, and randomly oriented.

Unit 5: Clast-supported diamicton with a sandy matrix (Unit 5, Figure 30) overlies Unit 4 at the south end of the main highwall. Clasts are up to small-cobble size and are weakly to moderately imbricated, tending to dip to the southwest (Figure 37). Crude horizontal beds, up to 1 metre thick, exhibit normal grading, some with a thin, inversely graded zone at their base. Minor openwork, moderately well sorted, pebble beds occur. A large trough-shaped lens of diamicton is exposed within the upper part of Unit 5.

Unit 6: In the centre of the mine site the lower gravels (Unit 3) are unconformably overlain by chaotic to weakly imbricated, poorly sorted, large cobble to boulder gravels fining upward into pebble gravels (Figure 27). Crude horizontal stratification dominates but beds locally dip up to 10° to the south. Beds are up to 2 metres thick and bed boundaries are discontinuous and gradational. Clasts are mostly angular to subangular, especially near bedrock highs, but rounded cobbles and boulders dominate some beds. The number of striated and erratic clasts increases toward the top of the unit.

Unit 7: Unit 7 (Figure 30) is generally 2 to 8 metres thick and consists primarily of massive, dense, matrix-supported diamicton. Clasts, often striated, are up to cobble size with rare boulders. They are mostly angular to subrounded with shattered and broken clasts common. The matrix is sandy silt. The lower contact of the diamicton is sharp and planar to gently undulatory. The diamicton is highly variable in its sedimentary nature. At Section F, silty diamicton and horizontally laminated sandy silts are interbedded at the

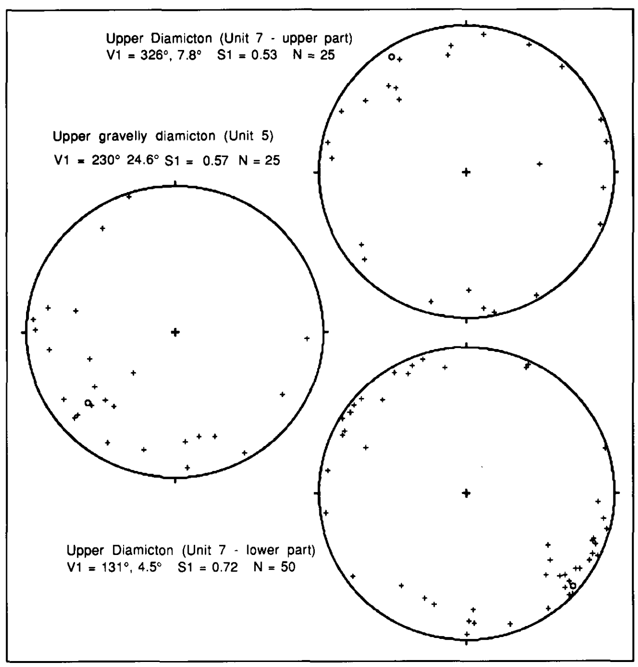


Figure 37. Stereoplots illustrating the dip of the intermediate axes of blade and disk-shaped clasts in gravelly diamicton (Unit 5), and the trend and plunge of the a-axes of elongated clasts in the upper and lower parts of Unit 7 at the Ballarat mine (Location 29). V1 = orientation of maximum clustering (shown with a small circle) and S1 = normalized eigenvalue for V1.

base of the unit. They have few pebbles and some fine sandy laminae. In exposures west of the main highwall, the diamicton contains a 2-metre-thick stratified zone with diamicton beds, of variable clast content and matrix texture, interbedded with laminated clays, silts, and fine sands. The latter locally contains rounded silt intraclasts and exhibits convoluted laminae. Irregular gravelly lenses occur locally. Clast fabric data from the lower part of Unit 7 indicate a strong preferred orientation of the long axis of clasts parallel to the main valley trend (northwest). Higher up in the diamicton clasts are more randomly oriented (Figure 37). The proportion of distal to local clasts in the diamicton decreases with depth.

INTERPRETATION

The gold-bearing deposits exposed along the main highwall of the Ballarat mine (Figure 30) are interpreted as alluvial fan and fan-delta deposits. Poor sorting, disorganized fabric, folded strata and angular clasts in diamicton beds of Unit 2 suggest a debris-flow origin with a local bedrock source. Previously rounded clasts were also incorporated into the flow deposits. Poorly sorted sediments with a fine matrix, disorganized fabric and gradational bed contacts are typical of modern debris-flow deposits (Bull, 1972; Kochel and Johnson, 1984). Folded and boudinaged beds of local material indicate only minor transport distance. Stratified sands and silts were probably deposited by fluvial activity between debris-flow events.

Lithologic analysis of the gravels in Unit 4 (Figure 37) and the general northerly dip of beds, indicate that they were derived almost entirely from a small tributary drainage to the south. The characteristically steep and consistent dip of beds and the topographic high to the south suggest a fan-delta environment. Laterally continuous, massive, steeply dipping, gravel beds with sharp planar contacts are typical of foreset beds. They pinch out or flatten in the down-dip direction and grade up-dip into overlying gravel (topset) beds. Massive or normally graded sands, horizontally laminated silts and ripple-bedded fine sands are common in subaqueous environments. Load, flame and injection structures indicate rapid deposition onto saturated sediments. Sand intraclasts, local concave scouring, convoluted bedding, faults, and other deformation structures probably formed as a result of syndepositional slumping on oversteepened foresets. Massive to normally graded sands and gravels may reflect small sediment gravity-flow deposits. Angular sand and gravel inclusions at the base of some beds are probably rip-up clasts. Poorly sorted gravel and diamicton beds in this unit are interpreted as gravelly debris-flow deposits (*c.f.* Larsen and Steel, 1978; Burgisser, 1984). Disorganized to weakly imbricated, large-clast clusters, such as those in the upper part of the unit, form during the waning stage of high-discharge events (Brayshaw, 1984).

Deformation in Unit 4 at the north end of the main highwall may be glaciotectonic in origin. High pore-fluid pressures in saturated sediments would result in deformation structures similar to those described. Compressive deformation would be expected along the margins of a glacier advancing down the main valley. This explanation is consistent with the observed decrease in deformation structures to the south.

Diamicton beds in Unit 5 are interpreted as debris-flow deposits. Poor sorting, normal grading with basal inverse grading, indistinct stratification and weak imbrication are typical characteristics of debris-flow deposits (Kochel and Johnson, 1984; Burgisser, 1984). Interbedded, sorted sediments indicate some fluvial activity between debris-flow events. Lithologic and imbrication data indicate that the flows originated from the topographic high to the southwest (Figures 37 and 38).

In the centre of the mine site, the lowest exposed pebble gravels (Unit 3) are interpreted as fluvial channel deposits. Low-angle planar crossbedding probably reflects deposition of the gravels along the channel margins or as bar foreset beds. Scoured contacts indicate locally channellized flows, possibly in a braided river system. Lithologic variability of these gravels in comparison with Units 4 and 5 (Figure 38) indicates that they were not derived solely from a local tributary, but rather were deposited in a main valley system.

The fining-upward sequence of gravels (Unit 6; Figure 27) unconformably overlying Units 3 to 5 is interpreted as channel-fill deposits. The coarse size of the gravels, high proportion of distally derived clasts (Figure 38) and dominance of crude sub-horizontal stratification suggest that they are glaciofluvial braided stream deposits (Church and Gilbert, 1975; Hein and Walker, 1977). The increase in striated and erratic clasts towards the top of the unit and the gradual fining-upward, and eventual abandonment of the channel probably reflect the advance of glacial ice into the region.

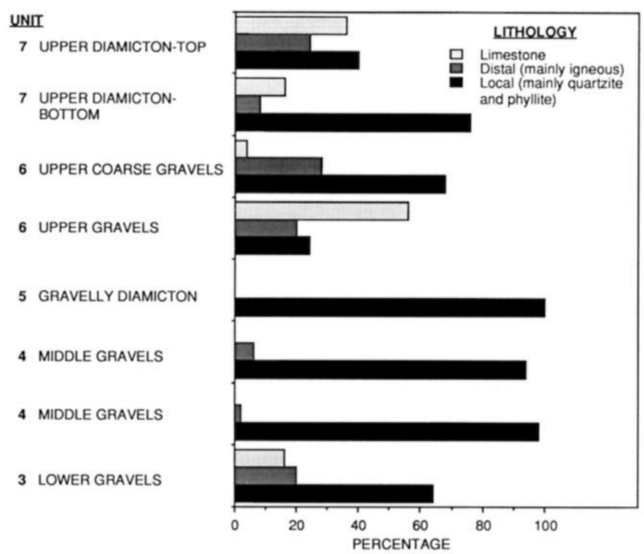


Figure 38. Lithology of main gravel and diamicton units at the Ballarat mine (Location 29). Note the abundance of locally derived clasts in the fan-delta deposits (Units 3 and 4), compared to the paleochannel deposits (Unit 3), glaciofluvial gravels (Unit 6) and glacial deposits (Unit 7).

The massive diamicton of Unit 7 is interpreted as till deposited at the base of an over-riding glacier. Its massive, dense, matrix-supported character is consistent with this interpretation. Diamictons with these characteristics, as well as with numerous striated and fractured clasts, a fine-grained matrix, a basal enrichment in local clasts, a strong a-axis fabric parallel to the main valley, and a sharp, planar lower contact, are typical of basal lodgement and melt-out tills in mountain regions (Levson and Rutter, 1988 and references therein). Thin lenses of laminated clay, silt and sand are probably the result of pond sedimentation in small cavities at the glacier base. Diamictons interbedded with these sorted sediments were probably deposited as small debris flows within the cavities or by melt-out of debris from the glacier base. Poorly defined gravel lenses may have been deposited in small cavities by subglacial streams. The random orientation of clasts in the upper part of the diamicton (Figure 37) may be a result of resedimentation during postglacial times. Colluvial activity did not disrupt primary depositional characteristics in the lower part of the till.

SUMMARY OF GEOLOGIC EVENTS

The sequence of deposits exposed at the Ballarat mine suggests that the following geologic events occurred during the late Quaternary. Prior to the last glaciation in the area, a bedrock-incised channel was occupied by a braided river that deposited the lower gravels in the centre of the mine (Unit 3). Coeval sedimentation along the margins of the channel was dominated by locally derived debris-flow deposits (Unit 2, Figure 30). Possibly as a result of the onset of glaciation, drainage in the vicinity of the mine was impeded, allowing development of a small fan-delta (Unit 4). Deposition of steeply dipping gravel and sand foreset beds initially dominated infilling of the channel. The upper gravelly diamicton (Unit 5) was deposited largely by a series of debris flows derived from the highlands to the south. The increase in locally derived debris-flow material, possibly due to the reduction in vegetative cover associated with glacial conditions, reflects the progradation of alluvial fan sediments over the area. Coarse, glaciofluvial gravels (Unit 6) and basal lodgment and melt-out tills (Unit 7) were deposited with the advance of glaciers. Some deformation of the underlying sediments occurred with the advance of ice. Sorted sediments were deposited locally in subglacial cavities. Subsequent to deglaciation, resedimentation by colluvial processes was restricted to the upper part of Unit 7.

PLACER POTENTIAL

The exact location, extent and orientation of paleochannels in this area have not been determined despite an extensive drilling program. The geomorphic setting is such that the paleostream that deposited the lower auriferous gravels at the Ballarat mine may have flowed either through the pass occupied by Weldon Lake into Pleasant Valley Creek or down the Williams Creek valley. Detailed paleocurrent studies of the lower gravels should be conducted during mining to help locate the downstream extension of the paleochannel. The old hydraulic operation at this site presumably exploited gravel in a paleotributary of the Williams Creek channel. Other tributary systems of the main valley paleochannel also may occur elsewhere in the area.

The large deposit size, relatively high gold concentrations and thin overburden suggests that buried alluvial fan and fan-delta deposits may be good exploration targets near this site and elsewhere in the Cariboo region. Exploration activities should focus on identifying and investigating sites downstream from productive paleogulch channels in areas protected from glacial erosion by bedrock highs.

Gold concentrations are up to approximately 2 grams per cubic metre in gravels of Unit 4, 0.6 gram per cubic metre in gravelly diamicton beds (Units 2 and 5), and 0.1 to 0.2 gram per cubic metre in the upper diamicton (A. Ball, personal communication, 1989). The upper diamicton (Unit 7) is presently considered to be overburden but may be mined in the future using improved gold recovery techniques.

GROUSE CREEK (Location No. 30, Figure 7)

SITE DESCRIPTION

Grouse Creek was the site of extensive mining in the 1800s and early 1900s with most activity occurring downstream from Shy Robin Gulch. Mining was concentrated along the Heron channel which follows the general trend of Grouse Creek (*see* Location 17) and along a paleochannel known as the Waverly channel which flows parallel to Antler Creek. The Waverly channel was entirely obscured by overburden and was discovered by sinking shafts in 1867. It was subsequently mined for many years by both underground and hydraulic methods. The paleochannel has a gradient as low as 1.5% and is believed to be an old channel of Antler Creek (Johnston and Uglow, 1926).

Section 9030 (Appendix 2) is located at the lower end of an old hydraulic pit that was opened up in an attempt to reach the buried Waverly channel deposits. Reported gold recovery was low and hydraulicking was hindered by the low gradient of the channel and by a hard bouldery clay (till) unit overlying the channel gravels.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

The sequence of deposits exposed at Section 9030 (Appendix 2) is interpreted as fluvial and glaciofluvial gravels deposited prior to the last glaciation. The lowest exposed gravel units (1 to 8) are well imbricated indicating a southeasterly paleoflow, similar to the modern creek, and probably represent an aggradational phase of the old channel. The absence of a coarse gravel lag at the base of the sequence suggests that there was no significant period of erosion prior to deposition of the basal gravels and they probably are not highly auriferous. Units 10 and 11 are interpreted as proglacial outwash gravels that grade upward into till and glacially derived debris-flow deposits. Gold-bearing gravels stratigraphically underlie this entire sequence as well as a lower till unit described by Johnston and Uglow (1926) and, are probably preglacial in age.

There is some potential in this area for the discovery of buried gravels related to both the Heron paleochannel and the Waverly cross-channel. Possible unexploited gold-bearing gravels underlying the hard till unit in the base of the old hydraulic pit may be mineable by mechanized open-pit techniques, unavailable to miners in the early 1900s. The upstream extension of the Waverly channel, towards the head of First Chance Creek, was drilled but the low gradient prevented hydraulic mining. The downstream extensions of both paleochannel systems have never been found and may have been partially or entirely eroded by glaciers moving down the Antler Creek valley. The downstream extension of the Heron paleochannel system presumably terminated in an alluvial fan in the old Antler Creek valley where it probably consisted of several paleofan channels with gold grades progressively decreasing down fan. Determining the probable location of the downstream extension of the Waverly paleochannel (or old Antler Creek valley) is more problematic. Because the paleochannel occurs at a higher level than the modern Antler Creek valley, its possible orientation is not entirely constrained by the present topography. It may have continued beyond the Waverly pits north into the Maude Creek drainage or northwest into the headwaters of Canadian Creek, or it may have turned northeast, parallel to to the modern Grouse Creek valley. Geomorphic and topographic analysis of the area suggests that any or all of these channel orientations may have been possible at different times. A paleochannel following a northwest-trending topographic low extending from the head of First Chance Creek to the head of Canadian Creek could have developed early in the drainage history of the area. A paleochannel flowing into the Maude Creek drainage may have developed later and the most recent system, being most constrained by the modern topography, probably would have drained into the present Grouse Creek valley.

The local bedrock along lower Grouse Creek, as well as along Maude Creek and most of Canadian Creek, is mainly siltite and phyllite of the Hardscrabble Mountain succession (Figure 7). Downey succession rocks, believed to be one of the main bedrock sources of placer gold in the region, do not occur in these areas. Much of the gold in paleochannel gravels in this region was therefore probably derived from rocks to the west and gold concentrations presumably decrease to the east.

CUNNINGHAM CREEK (Location No. 31, Figure 8)

SITE DESCRIPTION

This property is located on the west side of Cunningham Creek approximately 20 metres above river level. The area is well known for its gold production and historically supported as many as 300 miners at one time. Most of the gold was mined along the valley bottom in a buried paleochannel located about 100 metres from the modern stream. Auriferous gravels, 0.3 to 2 metres thick, in a small bedrock depression approximately 10 metres long, had a reported production of 18 500 grams of gold. The depression extends from the west side of the valley down to Cunningham Creek and may have been a small gulch-like tributary channel oriented perpendicular to the main channel.

GEOLOGY

The local bedrock is schist, slate and siltstone with some thick concordant barite and quartz veins up to 2 metres wide. Beds dip 70° to 90° to the southwest and strike at approximately 140°. Beds are locally folded and have a well-developed foliation. Small discordant quartz veins contain some malachite. The Pleasant Valley thrust crosses Cunningham Creek near this site (Figure 8) and a distinct change in gold size occurs along this portion of the creek, with coarser gold occurring upstream.

Glacial erosion has removed much of the surficial cover in the vicinity of this property and striated bedrock is exposed in the area. Matrix-supported diamicton and poorly sorted gravel units exposed on the valley side are interpreted as till and glaciofluvial deposits, respectively. Gold has been mined from glaciofluvial gravels occurring directly below and above till in the area and concentrations ranging from approximately 0.5 to 4.0 grams per cubic metre have been reported (Johnston and Uglow, 1926). Particles are flattened, worn and mainly fine, suggesting that they were glacially transported. Ice and glacial meltwater apparently eroded the auriferous paleochannel gravels in some areas and transported the gold down-valley. Gold recently recovered from surface gravels in the area probably reworked from glacial deposits by colluvial and fluvial processes.

The current mine is recovering gold from thin basal gravel units in bedrock lows. The gravels are compact, poorly sorted, locally cemented and grade laterally into sandy diamicton. They are overlain on the valley side by a matrix-supported diamicton and an upper, crudely stratified diamicton with numerous, locally derived, angular clasts. The gold is angular and is described as 'sugar-like', with some very fine vein and crystalline gold. Coarse nuggets, varying from approximately 0.2 to 2 centimetres in diameter, have been found near the surface. Most of the gold is mined near the valley bottom in areas below small paleo-gulches or in lows areas in the bedrock on the valley side.

PLACER POTENTIAL

A small bedrock high on the west side of the valley at this site separates Cunningham Creek from a possible buried channel to the west. Excavations in the area have exposed wood from several old shafts, one of which is reported to be about 12 metres deep. Although the area has been extensively mined, there remains some potential for the discovery of remnant paleochannel deposits as early miners had difficulty in tracing and working the buried channel deposits (Johnston and Uglow, 1926). Small bedrock depressions such as the one described above are potentially difficult to locate but may have exceptionally high gold concentrations. The depth of burial of the paleochannel increases both upstream and downstream of this site (Bowman, 1895) but the degree of preservation of the old gravels from glacial and glaciofluvial erosion is not known.

High gold concentrations occurring in placer deposits in the immediate vicinity of this property may be related to the Pleasant Valley thrust fault. A local source is suggested by the large size and high angularity of nuggets and the presence of fragile gold. The decrease in the grain size of gold downstream from this site also suggests that the bedrock source(s) may be local.

LATE WISCONSINAN GLACIAL AND GLACIOFLUVIAL PLACERS; (Locations 32 to 39)

COULTER CREEK HYDRAULIC PIT (Location No. 32, Figure 7)

A thick sequence of interbedded sands, gravels and diamicton is exposed at this abandoned mine (Plate 37). The lowest exposed sediments are laminated sands and silts and poorly sorted gravels (*see* Units 1 and 2, Section 9032, Appendix 2). They are interpreted, respectively, to be nearshore glaciolacustrine sediments and proximal glaciofluvial outwash deposits. These deposits are overlain by a thick deposit of massive, sandy diamicton with abundant striated clasts (Unit 4) interpreted as till. The till has an erosional lower contact and shear structures and faults in the underlying sands and gravels are probably the result of glaciotectonism induced by the over-riding ice mass. Planoconvex lenses of cobble and boulder gravel (Unit 3) at the base of the till are interpreted as subglacial tunnel deposits. Overlying the till deposit are sandy glaciofluvial sediments (Unit 5) from an ice-proximal shallow, braided stream. A paraglacial sequence of resedimented glacial diamicton and poorly sorted glaciofluvial deposits caps the section (Units 6 to 8, Section 9032, Appendix 2). Diamicton interbeds in sand and gravel units are probably colluvial debris-flow deposits derived mainly from the valley walls.

Plate 37. Complex sequence of interbedded sands, gravels and diamicton exposed at the Coulter Creek mine site (Location 32). Deposits of inferred glaciolacustrine, glaciofluvial and glacial origin are overlain by a paraglacial sequence of resedimented glacigenic deposits and postglacial colluvial debris-flow deposits. Man at lower right for scale.

Gold production from this creek is reported to have been 31 567 grams (Holland 1950). Most of the gold was probably recovered from Holocene gulch gravels. Paleogulch gravels may also occur in the area but they stratigraphically underlie the presently exposed Quaternary sequence (Plate 37). Johnston and Uglow (1926) reported a buried channel, on the southeast side of the valley opposite the first tributary, that was mined underground, but the extent and grade of the deposit are unknown. Auriferous paleogulch gravels may still be present above the head of the old hydraulic workings. Postglacial colluvial sediments in the area may also contain some gold, as in the nearby Nelson Creek drainage, but buried paleogulch gravels are more likely to have high gold concentrations.

MAUDE CREEK (Location No. 33, Figure 7)

This property is located on a series of broad benches on the south side of Pleasant Valley Creek near the mouth of Maude Creek. Bedrock is exposed near the rim of the upper bench and drops towards the south, possibly defining the northern margin of a buried channel. The bedrock low is mainly infilled with diamicton beds that dip towards the valley side to the south. The lower diamicton (Figure 31A; Unit 1, Section 9033, Appendix 2) is interpreted as a basal till. Overlying diamicton beds (Unit 2) are crudely stratified, contain minor gravel lenses and are interpreted as debris-flow deposits. Postglacial lacustrine silts, peat bog deposits and terrace gravels (Units 3 and 4) locally cover the bench.

Gold has been recovered from the bedrock and overlying diamicton units, as well as from a gravel layer which occurs intermittently between Units 1 and 2. In the bedrock, gold concentrations occur in fractures and on the surface. Gold in the diamicton beds is believed to have been derived from local bedrock sources as well as possible paleochannel gravels and incorporated by over-riding glaciers. Gold in the gravelly interbeds was presumably reconcentrated from the lower diamicton by small glaciofluvial streams. Reported assay results on the upper silt (Unit 3) suggest that it contains substantial quantities of fine gold. The unusually high gold values in diamicton and silt beds at this site can not be easily explained by fluvial activity and suggest a local gold source. It is not known if glaciers entirely eroded the original source but it may be possible to determine its location by searching for increasing gold concentrations in the up-valley (up-ice) direction.

CUNNINGHAM CREEK MINE (Location No. 34, Figure 8)

SITE DESCRIPTION

This mine is located on the east side of Cunningham Creek just upstream from its confluence with Cunningham Pass Creek. Several old shafts and drifts were apparently constructed to mine paleochannel gravels in bedrock lows. One shaft on the west side of the creek was 30 metres deep, from which a drift followed gold-bearing gravels for approximately 150 metres (Johnston and Uglow, 1926).

Quartzite bedrock of the Yanks Peak Formation is exposed on the southeast side of the active pit. The bedrock surface drops steeply toward Cunningham Creek and occurs at about 30 metres depth in a drill hole on the northwest side of the creek. A composite stratigraphic column was constructed from several exposures at this site (Figure 31B). In the valley centre, bedrock is overlain by interbedded gravel, sand and diamicton. The lowest exposed deposits are gravels (Unit 1, Section 9034D, Appendix B) overlain by a thin, massive diamicton (Section 9034D, Unit 2). A complex sequence of thin gravel, sand and diamicton beds (Figure 39; Sections 9034E, C, CW, W and S, Appendix B) stratigraphically overlie the lower gravels. These deposits are unconformably capped by a compact, bouldery diamicton sequence (Figure 31B). The lower part of the diamicton sequence is extremely difficult to strip and has prevented deeper excavations in some parts of the mine. This unit is sub-horizontal and is laterally traceable to bedrock on both sides of the valley.

The surface diamicton contains approximately 0.3 to 0.7 gram of gold per cubic metre but the lowermost diamicton bed has little gold. Gold concentrations are patchy and there is no noticeable increase over bedrock in some areas. Localized lenses or pockets of gravel contain up to 30 to 60 grams per cubic metre of gold but the lenses are generally small, averaging about 25 cubic metres. The gold-bearing sediments contain abundant pyrite (about 10 to 40 kilograms per cubic metre). The diamictons have reported assay values up to approximately 2 grams per cubic metre but recovered gold is significantly lower, presumably because much of the gold is chemically bound with the pyrite. Gold grains are mainly less than 1 centimeter in diameter and commonly flattened with rounded edges, with only some angular gold. Nuggets up to about 60 grams have been found.

GEOLOGICAL INTERPRETATION

The auriferous diamicton beds that occur at the surface in this area (Units 1 and 2, Section 8934, Appendix 2) are interpreted as basal tills. Much of the gold recovered from the till was probably eroded from bedrock and paleochannel sources by glaciers moving down the Cunningham Creek valley. Gravel pockets with higher gold concentrations may be blocks of the original gold-bearing gravels that were incorporated into the ice and redeposited down valley. The presence of gold in the upper part and not the base of the till suggests that the gold source was some distance up valley rather than in the immediate vicinity of the mine.

Gravel and sands units underlying the surface till (Figure 39; Sections 9034D, E, C, CW and W, Appendix 2) are interpreted as glaciofluvial stream sediments deposited in a

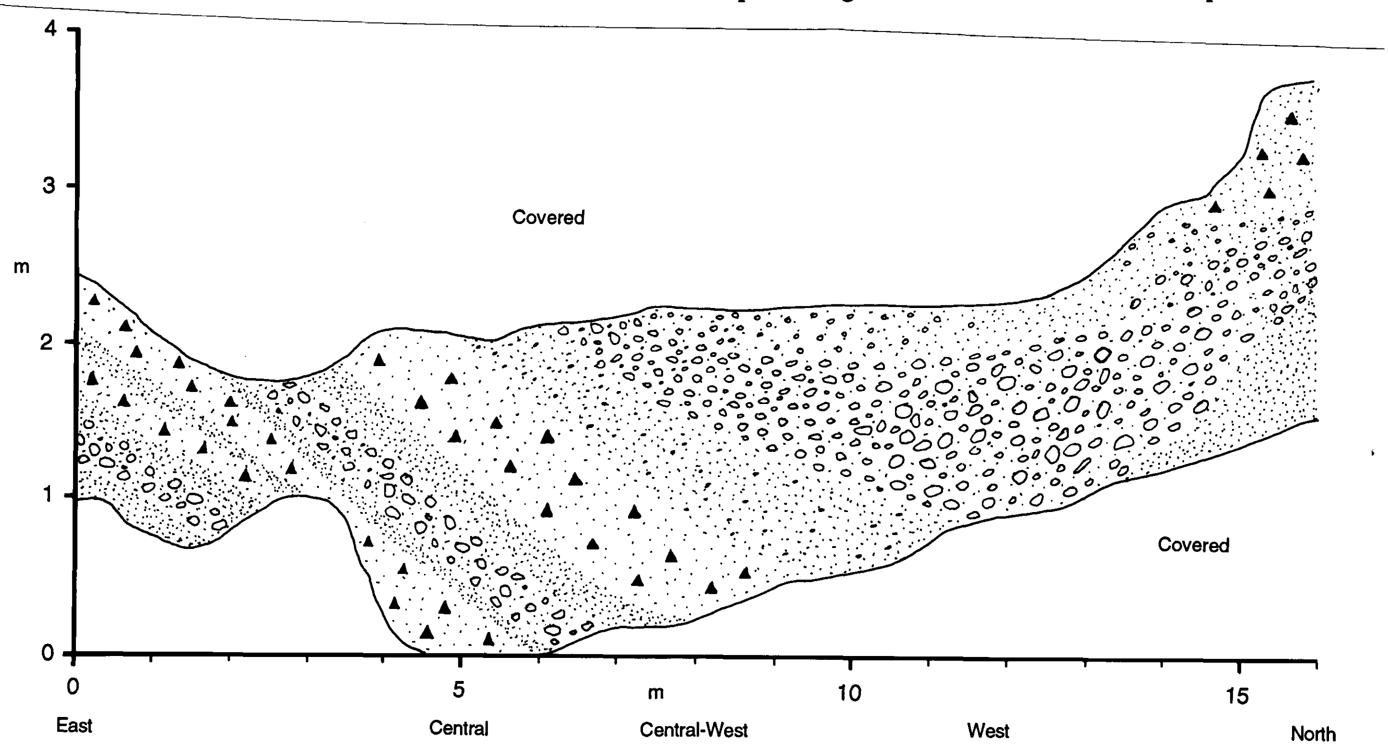


Figure 39. Pre-Late Wisconsinan, gravel, sand and diamicton sequence exposed in the valley centre at the Cunningham Creek mine (Location 34). Labels at base (East, Central etc.) refer to Sections 9034E, C, CW, W and S, described in Appendix B. *See* Figure 14 for legend.

channel system more or less paralleling the modern valley. Interbedded diamicton units are inferred to be episodic debris-flow deposits. Fabric analysis of the diamicton beds and slickenside trends indicate a debris-flow origin with slumping from the valley sides. Beds within the valley-fill sequence also dip towards the valley centre (Figure 39). Gold concentrations are highest, as expected, in gravelly beds where more washing has occurred. The age of these interbedded gravel, sand and diamicton deposits is unclear due to removal of the upper part of the sequence by mining activities, but stratigraphic and topographic relationships suggest that deposition occurred prior to the last glacial advance in the area.

There is potential for the discovery of paleochannel gravels with high gold concentrations in the valley centre, but such channels are probably narrow and deeply buried. Paleochannels at slightly higher levels on the valley side and farther up the valley may also exist but their preservation potential is considered low due to the increased effects of glacial erosion in these areas.

SNOWSHOE CREEK (Location No. 35, Figure 9)

GEOLOGY

Local bedrock at this site is olive and grey micaceous quartzite, phyllite, slate, limestone and meta-tuff of the Ramos Creek succession (Struik, 1987). This assemblage occurs in a westerly dipping belt that parallels Keithley and Snowshoe creeks and overlies similar rocks of probable Hadrynian age on the west slopes of Yanks Peak. More than 155 000 grams (5000 oz) of gold were recovered by Cariboo-Hudson Gold Mines Limited between 1936 and 1939 (Holland, 1954) from rocks of the Downey Creek succession, a probable lateral equivalent of the Ramos Creek succession (Struik, 1987). Gold-bearing quartz veins occur on Yanks Peak and exploration for lode gold sources in the Keithley and Snowshoe creeks area is still active. Keithley and Little Snowshoe creeks were the most productive placer creeks in the area. The total recorded production of placer gold from the region between 1874 and 1950 was over 2 million grams (69 237 oz) with actual production probably four to five times greater (Holland, 1954).

The basal deposit of interbedded sand, gravel and diamicton at this site (Unit 2) is interpreted to be a sequence of proximal glaciofluvial sediments and debris-flow deposits. These sediments fill topographic lows and are overlain by a thick diamicton sequence (Unit 3) interpreted to be till and associated debris-flow deposits. The thickness of the diamicton and presence of striated clasts suggests a glacial provenance. Stratification and high clast content in some beds indicates that the till has been locally resedimented as a result of slope processes. The lower contact of the till is apparently erosional and the directly overlies bedrock in places.

PLACER POTENTIAL

Placer exploration in recent years has targeted possible buried-channel systems that parallel Snowshoe, French Snowshoe and Keithley Creeks. A drilling program and seismic surveys were conducted in the area in the mid-1980s. Results from holes drilled with a reverse circulation, air-rotary drill indicate the presence of red-stained gravels under till (Hilchey and Mitchell, 1986). One hole drilled in the bottom of the French Snowshoe valley about 350 metres upstream from the confluence with Snowshoe Creek, encountered 14.5 metres of till and 2.6 metres of dry gravels overlying bedrock. The results of the seismic surveys also suggest that there is good potential for the discovery of auriferous paleochannels buried below till in the area (Hilchey and Mitchell, 1986).

GOLD CREEK AREA (Location No. 36, Figure 6)

GEOLOGY AND GEOMORPHIC SETTING

The Gold Creek property is located near Hay Lake in the Ahbau Creek valley (Figure 40). A north-south oriented meltwater channel joins Gold Creek just upslope from a small alluvial fan built out into the Ahbau Creek valley at the south end of Hay Lake. The fan apex is at the confluence of the Gold Creek valley and a small meltwater channel extending to the south. The fan is comprised of sediment derived from these two valleys. Erosion of any gold-bearing deposits in either or both valleys would have resulted in gold deposition at the fan head. Based on air photo analysis of fluting orientations, regional ice-flow direction was northeasterly (50° - 65°), at least during the latter stages of glaciation (Figure 40). As glacial deposits would have filled any

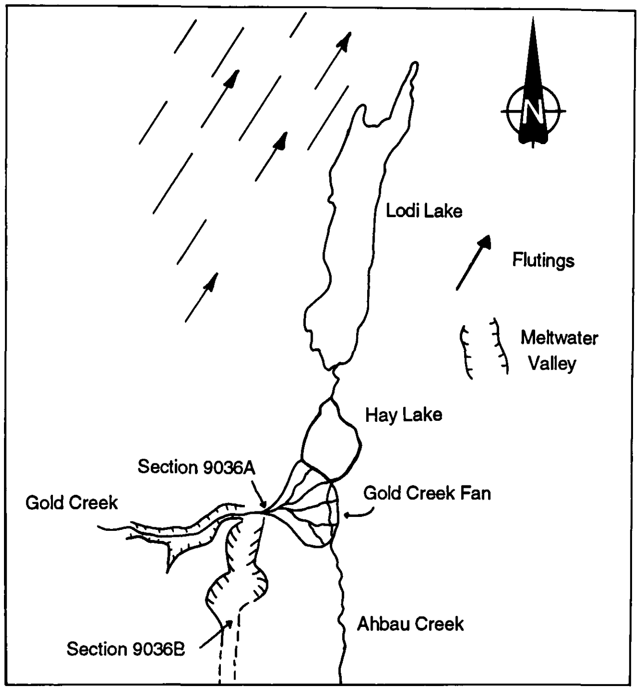


Figure 40. Distribution of landforms and measured sections (9036A, B) in the Gold Creek area (Location 36). Auriferous gravels occur in the postglacial, Gold Creek alluvial fan and in glaciofluvial deposits within the meltwater channel south of the fan.

small pre-existing valleys oriented obliquely to ice flow, the meltwater channel must have been cut during deglaciation. Gold occurs sporadically throughout the sequence in gravel dominated lithofacies. Reported grades vary from approximately 0.25 to 0.5 gram per cubic metre. Gold grains range in diameter from 0.01 to 0.5 centimetre with an average of about 0.05 centimetre.

Section 9036A (Appendix 2) was described in a mine exposure (Plate 38) near the apex of the Gold Creek alluvial fan-delta. Massive to crudely stratified, poorly sorted gravels (Units 1, 2, 6, 8 and 9, Section 9036A, Appendix 2) are interpreted as debris-flow deposits. Poor sorting, crude imbrication, high proportion of fines in the matrix and inverse grading are all characteristics typical of debris-flow deposits. Interbedded horizontal and planar crossbedded sands and gravels (Units 3, 4, 5 and 7, Section 9036A, Appendix 2) were deposited by intermittent fluvial activity between episodic debris-flow events. Sedimentation patterns of this type are typical of alluvial fan environments. Sedimentation probably was most active during and shortly after deglaciation. The highest grades should occur in deposits at the fan apex where the stream gradient decreases most sharply. Additional pay gravels may occur further down the fan along former, main fan-channel stream courses.

Section 9036B (Figure 31C; Appendix 2) is near the head of a small meltwater channel that joins a larger system to the north. Several test pits throughout the area reveal a similar stratigraphic sequence to that exposed at Section 9036B (Appendix 2). Units 1 to 3 are mainly barren, well-sorted, well-rounded gravels of fluvial or glaciofluvial origin. Horizontally laminated silt and clay of Unit 4, containing dropstones locally up to boulder size, are probably glaciolacustrine in origin. Gold was concentrated in Unit 5 gravel from preexisting sediments that were eroded from upstream reaches of the channel by glacial meltwaters. Gold is most concentrated at the base of the gravel overlying the clay and reported gold values are approximately 1.3 to 2.6 grams per cubic metre. The size range of gold grains is similar to that in the fan deposits but the gold tends to be coarser with an average grain diameter of about 0.2 centimetre. Unit 6 sands are interpreted as low-energy fluvial sediments deposited during waning stages of meltwater flow and do not contain gold in economic concentrations.

PLACER POTENTIAL

Mining of gold from Unit 5 gravels (Section 9036B, Appendix 2) may be viable as there is minimal overburden and gold concentrations appear to be consistently high in the surface gravels. Although a mining operation in this area would be constrained by the limited thickness of the gravels, their areal extent may be sufficient to support a small mine. Mining of any gold-bearing gravels below 10 metres depth may be prohibitive due to the thickness of the overlying barren gravels. Although the lower gravels at this site apparently do not contain high gold concentrations, older gold-bearing gravels may have been exposed and eroded elsewhere along the length of the meltwater channel. Fur-

Plate 38. Typical alluvial fan deposits exposed near the apex of the Gold Creek alluvial fan-delta (Location 36). Poorly sorted, debris-flow deposits are interbedded with stratified sands and gravels deposited by intermittent fluvial activity between debris-flow events.

ther study of any exposures along the channel walls may locate gravel units from which the gold was derived.

TREGILLUS LAKE MINE (Location No. 37, Figure 10)

SITE DESCRIPTION

This property is located along the east shore of Tregillus Lake in the Beaver Pass valley. The mine site is in a broad, flat part of the valley with occasional bedrock highs. Surface gravels have been extensively mined between the bedrock highs. On the eastern side of the mine, near the location of the measured section (Section 9037, Appendix 2; Figure 31D), the original topography was hummocky.

Bedrock is a garnetiferous schist. Depressions and crevices in the bedrock are filled with well-rounded gravels that are cemented with iron and manganese oxides and contain up to about 3.5 grams of gold per cubic metre. Coarse gravel in the upper 1 to 2 metres has a reported gold content of approximately 0.5 gram per cubic metre. The underlying 1 to 2 metres of pebble gravel contains 0.2 to 0.3 gram of gold per cubic metre. Gold is mostly 1 to 2 millimetres in diameter, with about 10% being coarser and 15% finer. Grains up to 5 grams are common and the largest recovered nugget is 45 grams. Gold size is believed to generally increase upstream (to the south) in most places.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

The mined gravels at this site are interpreted to be glaciofluvial gravels deposited during deglaciation. The wide range in clast lithologies, sharp changes in grain size and sorting from bed to bed, and an association of kettled topography with some of the gravel deposits, supports a glaciofluvial origin. The coarse bouldery gravels at the surface contain the highest gold concentrations and probably are lag deposits resulting from high-flow events prior to final abandonment of the glaciofluvial system. Much of the gold in the gravels may have been originally eroded from paleochannel gravels up the valley (to the south) by glacial and glaciofluvial processes. Gold has been mined at a number of properties south of this site, suggesting an up-valley source.

Two types of gold are reported: some is coarse and flat with a fineness of 900 to 910, and believed to originate from the Lightning Creek area. This gold is believed to be derived from an old channel of Lightning Creek which ran up the Beaver Pass Creek - Tregillus Lake - Willow River valley prior to its cutting a new channel past Wingdam. The miners also speculate that the reddish black stained gold (920 fine) is derived from a remnant buried paleochannel extending from the Mosquito - Willow River valley to the slopes above Tregillus Lake. Gravels on the eastern valley wall are auriferous but the origin of this gold is not known. Although gold grades in the glaciofluvial deposits at this site are relatively low, the deposit is of large volume.

The potential for the discovery of buried paleochannel gravels in this area and in up-valley locations is good although any such deposits may have been heavily eroded by glaciers and glacial meltwater. Deep excavations in the glaciofluvial gravels at this site have revealed coarse gold-bearing gravels overlying bedrock, but the age and extent of these deposits is not well established. Other than near-surface concentrations of gold, the glaciofluvial gravels are relatively barren and their removal to reach deep paleochannel gravels at this site has so far proven uneconomic.

PINUS CREEK PROPERTY (Location No. 38, Figure 7)

SITE DESCRIPTION

The mine site is located at the confluence of Shepherd Creek, Pinus Creek and an unnamed meltwater channel running parallel to, and just east of Pinus Creek. Shepherd Creek runs through a narrow bedrock-floored meltwater channel before joining Pinus Creek. Geomorphologically, the mine site is characterized by irregular (hummocky) undulations and bedrock-ridges. Large boulders are often present on the surface of small hillocks.

The thickest section at this site reveals approximately 4 metres of poorly exposed, interbedded sand and gravel unconformably overlain by crudely stratified diamicton; the shallow nature of the mining operation precludes good exposures. Soil development is common in the surface sediments, particularly iron accumulation in Bf and Bm horizons. Locally the gravels are cemented and contain strongly weathered igneous clasts that can be easily broken by hand. Local bedrock is phyllite and pyritized schist with crosscutting pyritic mafic dikes. Iron oxidation is locally well developed in the bedrock.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

The valleys occupied by Shepherd Creek and the unnamed creek east of Pinus Creek are typical channels cut by glacial meltwater. Much of the gold occurring in the area was probably originally concentrated by meltwaters flowing out of these channels into the Pinus Creek valley. Hummocky topography near the mine site suggests that some small blocks of glacial ice stagnated in the area during deglaciation. Sands and gravels carried into the area by meltwater may have been deposited around these ice blocks, accounting for the hummocky topography. Thin, surficial diamictons containing gold are probably glaciofluvial deposits, with reconcentration of the gold occurring as a result of resedimentation by colluvial processes.

The best gold values come from thin surficial sediments that veneer bedrock or cap sand and silt sections. Gold is reported to be most concentrated, and is mainly mined, on north and east-facing slopes. Higher gold concentrations on these slopes may reflect more active colluvial concentrating processes due to higher ground moisture (north and east-facing slopes being more shaded). The flattened and worn nature of the gold and its confinement to surface layers has been attributed by Johnston and Uglow (1926) to glacial transport and subsequent reconcentration by meltwater and postglacial streams. They reported gold concentrations up to 2.2 grams per cubic metre but the auriferous gravels only averaged approximately 1 metre in thickness, resulting in a difficult mining problem. The current mining operation successfully overcame this difficulty by utilizing a mobile processing plant (a combined shaker and sluice box on skids with a flexible water supply line).

The original source of the gold in the Pinus Creek valley is not known but one possible source is auriferous gravels in the upper part of Shepherd Creek, the main tributary of Pinus Creek. Gold-bearing gravels there occur in a buried paleochannel that may extend north to the Thistle pit (Johnston and Uglow, 1926) near Eight Mile Lake (Location 27). Gold transported down the Shepherd Creek channel by meltwaters would have been deposited in the lower Pinus Creek valley due to the decrease in stream gradient. The confinement of gold to surface gravels is compatible with this interpretation. Esker gravels in the area apparently do not contain significant quantities of gold.

CARIBOO RIVER PROPERTY (Location No. 39, Figure 12)

SITE GEOLOGY

This site is located on a series of terraces along the Cariboo River, directly downstream from its confluence with Spanish Creek. Gold occurs along a number of stratigraphic horizons including gravel strata underlying till, a coarse gravel unit (Unit 4, Section 9039C, Appendix 2) separating till and glaciolacustrine deposits (Plate 39) and in post-glacial terrace gravels. Gold has been mined from most of these stratigraphic levels at this and other sites in the region.

Bedrock exposed along the Cariboo River is a black argillite and outcrops to about 10 metres above water level. Approximately 10 metres of talus separates the outcropping bedrock from the lowest exposed Quaternary sediments on the south side of the river (at the base of Section 9039A, Appendix 2). The sequence consists of gravels at least 20 metres thick (Units 1 to 4) that coarsen upward from pebbles at the base to cobbles and boulders at the top. On the north side of the river the upper surface of the bedrock is well exposed and rises steeply toward the east. Bedrock does not outcrop on the uppermost terrace level but some large boulders believed to be bedrock blocks have been excavated from the base of trenches at the southernmost end of the bench (closest to the valley side). The boulders are mainly high-grade metamorphics (finely crystalline, mafic, foliated rock - probably amphibolite) with some argillaceous and schistose strata. Pyrite crystals up to 2 centimetres in diameter are common and some thin beds in the boulders contain up to 40% sulphides. The boulders oxidize readily.

GEOLOGICAL INTERPRETATION

The coarsening upward gravel progression at Section 9039A (Appendix 2) may reflect the advance of ice into the region from the south and the gravels, at least in the upper part of the sequence, are probably glaciofluvial in origin. Capping the gravel beds is a diamicton interpreted as till (Units 6 and 7) deposited by glaciers during the Late Wisconsinan. Horizontally laminated silt and clay with interbedded diamicton beds (Units 8 and 9) overlying the till are

Plate 39. Glaciolacustrine fine silt and clay beds sharply overlying channelized glaciofluvial deposits on a high bench along the Cariboo River (Location 39).

interpreted as glaciolacustrine sediments deposited in a large ice-dammed lake in the Cariboo River valley. Ice damming probably was due to a glacier occupying the valley. The glaciolacustrine sediments coarsen upward into sands with horizontal beds and small-scale trough crossbeds reflecting a progressive shallowing of the lake. These deposits are erosionally overlain by coarse terrace gravels (Unit 10) deposited by the Cariboo River, probably in early postglacial times. The river subsequently incised through the entire sequence to its present day level.

Exposures in the highest terrace or bench south of the Cariboo River (Sections 9039B and 9039C, Appendix 2) reveal an interesting sequence of glacial, glaciofluvial, glaciolacustrine and postglacial fluvial deposits. Massive, compact, matrix-supported diamicton with striated clasts overlying bedrock at the base of Section 9039C, is interpreted as a till and is correlated with till in the lower terrace (Section 9039A, Appendix 2). Gravelly sediments on top of the till (Units 1 to 6 at Section 8939B and Units 3 and 4 at 8939C, Appendix 2) are interpreted as proximal glaciofluvial deposits. These gravels have a pronounced erosional upper surface (Plate 39) that is sharply overlain by fine silt and clay beds (Units 7 to 9 at 8939B and Units 5 to 8 at Section 8939C, Appendix 2) inferred to be glaciolacustrine sediments deposited in an ice-dammed lake which filled the valley during deglaciation. Erosion of the gravel surface is presumably due to channel scouring prior to a rapid environmental change caused by ice damming. These sediments are equivalent to the glaciolacustrine deposits at Section 9039A (Units 8 and 9, Appendix 2). After the glacial lake drained, a braided stream paralleling the present day Cariboo River deposited sand and gravel on the upper terrace (Units 10 and 11 at 8939B and Unit 9 at Section 8939C, Appendix 2).

In summary, the sequence of Quaternary events recorded in the sediments at this site includes deposition of fluvial and glaciofluvial gravels in the Cariboo River valley prior to the last glaciation. These gravels were over-ridden by the Late Wisconsinan glacial advance. During deglaciation of the region, retreating ice dammed the regional drainage and created a glacial lake in the Cariboo River valley. Proximal glaciofluvial deposits were quickly covered by the expanding lake. After the lake drained, a series of high terraces were formed by the Cariboo River before the channel was incised to its present level.

PLACER POTENTIAL

There is potential for the occurrence of placer gold concentrations at several stratigraphic horizons in this area. Gravels underlying till have the greatest potential at depth as the upper part of the subtill gravel sequences was deposited in an aggradational glaciofluvial stream. The highest values are probably close to bedrock and along major unconformities in the gravel sequence. Till and glaciolacustrine sediments deposited during glacial and immediate postglacial times are probably poor prospects although gravels directly overlying or interbedded with these deposits may yield gold. The proximal glaciofluvial gravels that stratigraphically overlie till are gold bearing. Coarse lag-gravel concentrations within these deposits have the best potential. Terrace gravels also have potential where they have eroded through and reconcentrated gold from older auriferous deposits. Gold derived from upstream placer deposits may also occur in mineable concentrations on low postglacial terraces in the area. Low terraces have been mined in the region in the past and the upper terraces are currently being explored for placer potential.

LATE GLACIAL AND POSTGLACIAL, HIGH TO INTERMEDIATE-LEVEL TERRACE PLACERS (Locations 40 to 45 and 48)

MAN-MADE CREEK MINE (Location No. 40, Figure 7)

SITE GEOMORPHOLOGY

This mine is located on a bench on the lower slope of Burns Mountain above the old Ketch hydraulic pit. Hydraulic operations in the area, including those at the abandoned Ketch and China pits, have revealed narrow bedrock channels that trend both northerly, parallel to Devils Lake Creek and westerly, parallel to Slough Creek. One of the northerly trending channels is known as Lake Gulch. The channels occur between Burns and Devils Lake creeks well above the Slough Creek valley bottom. The base of the channel at the west end of the Ketch pit is about 15 metres above the modern level of Devils Lake Creek and base levels of the other paleochannels in the area also appear to be higher than present.

GEOLOGICAL INTERPRETATION

Massive diamicton that overlies bedrock at this site contains numerous angular rocks of local origin and is interpreted as colluvium derived from the valley side. Overlying gravel units are interpreted as glaciofluvial terrace gravels, probably deposited in ice-marginal channels during deglaciation of the area. These gravels contain some beds with numerous angular phyllite clasts indicating local erosion of bedrock by the ice-marginal streams. Variations in the texture and degree of sorting and imbrication in the gravels reflect variations in flow conditions. Gold within these deposits was presumably derived mainly from older gulch gravels and possibly also, to a minor extent, from local bedrock sources. Exposures of phyllitic bedrock within the hydraulic pits reveal numerous quartz veins, most of which are a few centimetres to tens of centimetres wide. Limonite filled vugs are common in the veins. Most of the veins are concordant with the northerly dipping foliation but sheared and faulted contacts are common.

PLACER POTENTIAL

The best potential for future discovery of placer gold in the area is in buried gulch channel deposits. In old hydraulic operations at this site, coarse gold was sporadically recovered mainly from paleochannel gravels overlain by till, and from bedrock benches above the channel (Johnston and Uglow, 1926). Gulch channels in the area are narrow, with channel bottom widths on the order of 10 metres. Overburden thicknesses are on the order of 10 to 15 metres and include both till and postglacial gravels. Surface gravels also have some mining potential, particularly downstream from intersections with paleogulch channels. Imbrication trends in the surface gravels indicate northeasterly paleoflow directions (Figure 41). Gold concentrations, downstream from paleochannel intersections, should therefore increase to the southwest and targets for further exploration may be identified there.

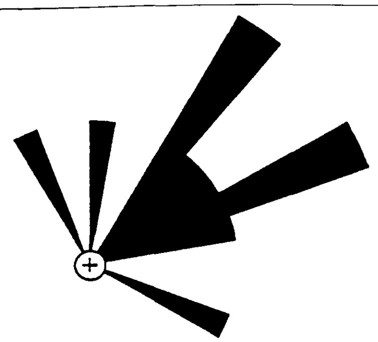


Figure 41. Rose diagram illustrating paleoflow direction, as determined from pebble imbrication data, in auriferous gravels deposited on a high terrace on Burns Mountain (Location 40).

BURNS CREEK MINE (Location No. 41, Figure 7)

SITE DESCRIPTION

This site is located on a high terrace along the south side of Slough Creek on Burns Mountain. The terrace is on the east side of Burns Creek and is confined by bedrock rising to the south on the valley side. The mineable terrace is approximately 50 metres wide and parallels Burns Creek. Stratigraphic columns of the terrace gravels exposed at this site are provided in Figures 33A and 33B and a representative cross-section is given in Figure 32.

The mined gravels at the west end of the terrace close to Burns Creek have a reported gold content of approximately 0.3 gram per cubic metre. In contrast, little gold was recovered from the terrace sequence at the east end of the mine site (only about 185 grams in approximately 4500 cubic metres or 0.04 gram per cubic metre). The bedrock slope above the terrace is reported to have a surface deposit of 'mud' approximately 1 metre thick with a relatively high content of fine gold. Gold in the area has a reported fineness of 920 and nuggets are moderately well rounded to subangular. Well-rounded flattened flakes are uncommon. Gold nuggets occur up to 1 centimetre in diameter and a 241-gram nugget has been recovered on the property. The gravels also have a significant, but variable proportion of fine gold.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

A colluvial layer of broken, angular schist blocks with a matrix of sand and pebbles typically overlies bedrock in this area. Gravels on top of this colluvial layer are moderately sorted and crudely to well bedded and are interpreted as glaciofluvial sediments deposited in an ice-marginal stream. The coarseness of these gravel beds and their sedimentary characteristics indicate high-energy, migrating flows with poorly defined channels and bars, typical of glaciofluvial streams.

The sequence of barren sands and gravels exposed at the east end of the mine site (Figure 33B; see Section 9041D, Appendix 2, for complete unit descriptions at this site) is thicker but otherwise similar to the auriferous deposits exposed to the west (Figure 33A; Sections 9041A, B and C, Appendix 2). The relative absence of gold at the eastern end of the mine site may thus be attributable to differences in proximity to a gold source. The auriferous gravels at western end of the terrace are closer to the modern Burns Creek channel and probably occur directly downstream from a gold-bearing paleochannel of Burns Creek from which the gold was derived. The gravels at the east end of the mine presumably were deposited by a stream that did not erode into an older gold-bearing gravel. The dip of beds in these glaciofluvial deposits suggest a north to northeast paleoflow similar to the trend of an esker complex directly east of this site (*see* also Location 7). As the east and west ends of the mine are not far separated, the location of the original gold source is relatively well constrained. However, it is not known if the gravels in that original deposit were entirely eroded by younger channels or if some of those auriferous sediments remain to be discovered.

The potential for the discovery of buried paleogulch channels in this area is good. Some seismic studies have been conducted and at least one bedrock channel has been identified. The channel bottom is approximately 20 metres deep and potential gold-bearing gravels at the base are buried by about 10 metres of till and 5 metres of surface gravels. The poor water supply in this area inhibited past hydraulic operations and some paleochannel deposits may remain. Exploration above the level of the old water supply ditch may also prove to be worthwhile.

CARBERRY CREEK MINE (Location No. 42, Figure 12)

SITE DESCRIPTION AND GEOLOGY

This site is located on a high terrace along the north side of the Quesnel River about 2 kilometres northwest of Likely. The terrace is approximately 1000 metres long and 400 metres wide and parallels the Quesnel River. The south-trending Carberry Creek valley joins the Quesnel River valley at this mine and is the site of an old hydraulic operation (Excelsior pit). Bedrock is exposed for approximately 100 metres along Carberry Creek above the terrace but drops sharply to the north (into the slope) near the Excelsior pit.

The terrace sequence exposed in the active open-pit mine (Section 9042A, Appendix 2) consists of thin diamicton beds over bedrock and a fining-upward sequence of gravel, sand silt and clay more than 5 metres thick. Crudely stratified cobble-gravels are overlain by two trough-shaped units of horizontally bedded pebble-gravel and fine to medium sand and by a unit of horizontally bedded silts and clays. These sediments are, in turn, unconformably overlain by a pebble gravel with a cap of massive silts.

Gold is reported to be of two main types: yellow, flattened flakes and green-yellow grains with a more equant shape. Nuggets are generally up to 15 grams and rarely up to 75 grams. Gold concentrations are highest in thin gravel units overlying bedrock or diamicton (till).

DEPOSITIONAL ENVIRONMENTS OF GOLD-BEARING STRATA

The three sections exposed at this site are each representative of a different type of depositional environment. Section 9042A (Appendix 2) is a good example of glaciofluvial terrace deposits, Section 9042B (Appendix 2) is typical of sedimentation in a gulch setting, and Section 9042C (Appendix 2) illustrates a cross-section through an alluvial fan deposit.

The basal sediments overlying bedrock (Unit 1) at Section 9042A (Appendix 2) are interpreted as a thin veneer of Late Wisconsinan till and debris-flow deposits (Units 2 and 3). The overlying sequence of deposits fining-upward from cobbles and pebbles at the base to sand, silt and clay at the top (Units 4 to 7) is interpreted as a channel-fill sequence in a glaciofluvial braided stream. Channelled pebble-gravels and sands in the upper part of the section (Unit 8) reflect late-stage flow across the terrace. The capping silts (Unit 9) are probably loess deposits confined to depressions on the terrace surface.

At the Excelsior Gulch section (Section 9042B, Appendix 2) the basal gravels and sands (Units 1 to 5) are interpreted as stream sediments deposited in a confined gulch setting. They directly overlie the bedrock and incorporate large angular blocks of limestone, siltstone and basalt. Southerly paleoflow data are consistent with this interpretation. The upper deposit at this section is a diamicton which is interpreted to be a Late Wisconsinan basal till. The high degree of compaction and the presence of fractured and crushed clasts are indicative of high pressures during and after deposition of the till. The upper part of the till has been resedimented by colluvial processes.

The Trench section (Section 9042C, Appendix 2) exposes a sequence of deposits interpreted as postglacial alluvial fan sediments formed where Carberry Creek emerges from its valley onto the terrace described above. The sediments coarsen upwards, reflecting the progradation of the fan onto the terrace. Beds consistently dip at 5 or 6° to the southwest (down fan). Crude stratification, poor sorting and large clast size in most beds indicate that they were deposited by debris flows or flood flows. A buried soil horizon in the upper part of the sequence separates the fan deposits from overlying tailings derived from previous mining operations in Carberry Creek.

POTENTIAL GOLD SOURCES

Gold concentrations in gulch and alluvial fan sediments at this site suggest a local source in the Carberry Creek basin, possibly related to bedrock faulting in the area. There is evidence of faulting and shearing in exposed bedrock along Carberry Creek (Section 9042B, Appendix 2) and a regional fault has been mapped in the area (Figure 12). The possibility of a large, northwest-trending buried valley cutting across the upper part of the Carberry Creek basin is also being investigated, but its presence is not yet proven. The disappearance of bedrock in the upper part of the Carberry channel and the existence of a northwest-trending topographic depression at the head of the creek suggest that such a transverse valley may exist. The extent of such a channel, its gold content and the possibility of it acting as a placer source for younger stream systems in the area is not known. The existence of such a regional paleochannel system may possibly be verified by investigating relationships between the deposits at this site with other mines in the area to the northwest and southeast.

In addition to a source in the Carberry Creek basin, gold occurring in terrace gravels at this site may have been transported from upstream sources along the Quesnel River. A dual source is supported by the apparent presence of two different types of gold. Flat gold flakes may have been derived from distal upstream sources in the Quesnel River drainage (or paleodrainage) and coarse chunky nuggets were probably derived from local bedrock sources along Carberry Creek.

WILLOW RIVER PROPERTY (Location No. 43, Figure 7)

This site is located on a broad terrace between the confluence of the Willow River and Slough Creek to the east of Island Mountain. The exposed sequence is dominated by crudely bedded, well-imbricated gravels and capped by sands. The gravels were probably deposited subsequent to the main postglacial aggradational phase in the Willow River valley. Subsequent migration of the gravel-bed channel of the Willow River allowed for progressive accumulation of gold along the basal unconformity of the old channel bed. The unconformity was not exposed and its depth is not known. Sand-dominated strata in the upper part of the sequence are interpreted as floodplain deposits that accumulated after the channel began migrating towards the other side of the valley.

Gold at this site has probably been recycled mainly from upstream placers in the Slough Creek and Willow River valleys and from tributary streams in these two valleys. Potential for coarse gold deposits exists in the lower part of the terrace sequence where the gravels may have eroded and reconcentrated older gold-bearing deposits. Cobble and large-pebble gravel beds overlying bedrock or clay-rich strata are the best targets. Some fine gold from upstream and valley side sources may also be present in the upper part of the terrace sequence. The location of this site at the confluence of two major stream channels may also be a factor in concentrating gold in the area.

QUESNEL RIVER, SOUTH FORK PROPERTIES (Location No. 44 and 45, Figure 12)

SITE DESCRIPTIONS

These sites are located on terraces approximately 75 metres above the Quesnel River south of Quesnel Forks. A number of shallow test pits were open at Location 44 due to an active exploration program, but the open-pit mine at Location 45 was inactive at the time of the property visit. Gold *nuggets were relatively well rounded and flattened.* Gold concentrations as high as 11 grams per cubic metre are reported to occur locally. The deepest test pit at Location 44 exposed approximately 3 metres of a clast-supported pebble to boulder gravel. It is mainly matrix filled and poorly sorted with some openwork beds. Clasts are moderately to well rounded. There are local concentrations of large boulders up to 2 metres in diameter and some large clasts are fractured but still intact. Large-clast clusters are associated with scoured channel-forms. The lower contact of the gravels is covered and depth to bedrock is unknown.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

The high elevation of these terraces relative to the level of the modern Quesnel River suggests that they were formed during deglaciation or in early Holocene times. Rapid aggradation of glaciofluvial gravels during these periods is common, with little opportunity for gold to concentrate. As a result, thick sequences of glaciofluvial gravels are usually barren. Placers can accumulate, however, at the end of the aggradational phase when significant stream-channel erosion may occur. Gold concentrations in the terrace gravels at these sites apparently occur mainly in the upper part of the gravel sequence at the base of large-clast clusters associated with major channel-scour facies. The large grain size and stratigraphic position of the gold-bearing strata indicate deposition during unusually high-flow erosive events prior to abandonment of the terrace level. Imbrication and the abundance of fractures in the large clasts suggests that they were transported as bedload in turbulent flows rather than by rafting in laminar debris flows. Some of the gold in these placer deposits was undoubtedly reworked from older paleochannel sources such as those in the Bullion mine directly upstream of these sites. During and after deglaciation, the Quesnel River presumably eroded some gold-bearing deposits at the southern end of the Bullion paleochannel. The proximity of these sites to those deposits may explain their anomalously high gold content.

HOLOCENE, LOW-LEVEL TERRACE PLACERS; (Locations 46 to 57)

FRASER RIVER PROPERTIES (Locations No. 46 and 47, Figure 6)

These sites are located on low terraces on the Fraser River north of Quesnel. Location 46 is on a small intermittent braid channel of the Fraser River that is occupied by the river only during high flow in the spring flood. Surface sediments are mined from the area where water from the main Fraser channel first enters the side channel. Gold is presumably eroded from the main Fraser River channel upstream from the site during high-discharge events and redeposited at the channel inlet where the water flow widens and shallows. The decrease in water velocity and depth results in a decreased competence and the heaviest materials in transport (including gold) are deposited first. The operation re-

Plate 40. Placer mine recovering fine gold from sand and gravel deposits on a point bar on the east bank of a large meander in the Fraser River north of Quesnel (Location 47) where gold is preferentially deposited during spring floods.

portedly works the gold-bearing surface sediments at the upstream end of the channel approximately every three years. Fine gold is recovered from a small portable sluice plant that reportedly produces on the order of 100 grams of gold per day.

Location 47 is on a large bend in the Fraser River (Plate 40) just downstream from its confluence with the Cottonwood River. A large point bar has formed on the east bank of the river on the inside of a large meander bend. Water flowing around the bend moves slowest on the inside and water depth is significantly less than in the main channel thalweg on the opposite side of the river. Gold is deposited on the upstream side of the point bar where velocity and water depth first decrease due to the decrease in competence of the river. Gold is presumably eroded from the modern river bed upstream from the site and may also be enriched by erosion of auriferous paleochannel gravels. A number of exposures of older gravels occur in the area and some are known to be gold bearing (for example at the Tertiary and Allstar mines upstream from the Cottonwood River and Fraser River confluence - *see* Location 2).

CORLESS MINE, QUESNEL RIVER (Location No. 48, Figure 6)

SITE DESCRIPTION

This site is located on a low terrace along the Quesnel River near Big Canyon, about 3 kilometres east of Quesnel. The Corless mine is exploiting low-terrace gravels that unconformably overlie older auriferous cemented gravel units, possibly of Tertiary age (*see also* Location 1). High gold values are reported from the base of coarse gravel units, particularly downstream of large boulders and natural ledges in the underlying cemented gravels.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

The gravels on this low terrace are interpreted to be Holocene fluvial deposits of the Quesnel River deposited prior to migration and down cutting of the present channel. The terrace is located just downstream from Big Canyon and forms a broad flat over which the river would have slowed and deposited the coarser and heavier fractions of its load. The coarse grain size of some beds, well-developed clast imbrication and scoured lower contacts are indicative of high-energy, turbulent, channelled flows. Gold is most concentrated in coarse gravel beds above erosional unconformities. The largest clasts in these beds are probably lag boulders remaining from erosion of older units. Zones of altered turbulence around boulders and downstream of natural riffles created by irregularities in the underlying cemented gravels are sites of gold deposition.

Cemented auriferous gravels of probable Tertiary age underlie the terrace gravels and can be seen in several exposures (*see* Location 1, Sections 8901 A, C/D, F, H, I and L, Appendix 2). They are believed to be the main source of the gold in the terrace gravels but some of the gold may also be derived from bedrock and other upstream sources. The presence of older auriferous deposits may be used as an indication of placer potential in terraces elsewhere along the Quesnel River in this region. Gold concentrations resulting from erosion and reconcentration of older gravels would be confined to sporadically occurring sites where the channels of the older streams and the Quesnel River coincide.

The site is located near a major fault separating the Quesnel and Cache Creek terranes and, therefore, potential for mineralized bedrock sources is high. In addition, the locations of paleodrainage systems and associated paleoplacer deposits in the area probably were significantly influenced by the presence of this fault.

LOWER QUESNEL RIVER PROPERTY (Location No. 49, Figure 6)

This site is located on a low terrace on the southwest side of the Quesnel River across the river and downstream from Deacon Creek. The terrace is about 300 metres wide, over 1000 metres long and occurs a few metres above modern stream level. The site has a mature forest cover and there is no evidence of flooding in recent years. The terrace is a broad alluvial braidplain of the Quesnel River and was probably cut during the late Holocene. At least 5 metres of well-sorted, well-rounded and well-bedded gravels have accumulated (Section 9049B, Appendix 2) on the terrace. The presence of coarse, massive gravel beds with scoured basal contacts, interpreted as channel lag deposits, indicates that numerous channels were formerly active on the terrace. The coarser fractions in these gravels represent active channel deposits of high-energy flows. Imbrication and crude horizontal bedding in some beds indicate deposition in longitudinal bars. Ripple-bedded sands interbedded with the gravels are interpreted as low-energy channel-fill and bar-top sands that formed as the flows waned or channels migrated. Massive to weakly laminated sands capping the terrace gravels at most sites are interpreted as overbank sediments deposited in flood conditions.

Concentrations of gold in these sediments are likely to be discontinuous with the highest values occurring in coarse gravel beds, particularly at the base of channel scours. Gold in these sediments has probably been transported downstream from sources in the Likely area and is dominated by fine-grained flaky particles capable of long distance transport. Some gold may also come from older gravels similar to those found at the Big Canyon sites (Location 48) but no exposures of mature cemented gravels were observed. In the absence of coarse gold from older gravel units or local bedrock sources, mining operations exploiting low-terrace gravels in this region must be capable of recovering mainly fine-grained gold from discontinuous sedimentary units.

LITTLE HIXON AND HIXON CREEK REGION (Location No. 50, Figure 6)

AREA GEOLOGY

The Hixon area has a number of historically important placer-producing streams including Hixon, Little Hixon, Terry and Government creeks, but no large operations were visited during this study. Some of the mined deposits in this area are buried by a thick succession of Quaternary sediments. At an old hydraulic pit on lower Hixon Creek approximately 5 metres of silt and clay are underlain by 15 metres of sand and gravel, and 20 metres of poorly exposed, matrix-supported diamicton. The sand and gravel has some large boulder concentrations and contains large inclusions of silt, clay and diamicton. Gold-bearing gravels occur stratigraphically below these deposits but are not exposed.

In addition to buried placers, a number of terrace placers have been mined in the area and most recent mining activity apparently has focused on these deposits. Small hand operations near the confluence of Little Hixon and Hixon creeks are exploiting low-terrace gravels. One section in a small mine exposed about 2 metres of oxidized, pebble to cobble gravel overlying bedrock. Individual beds are generally moderately to well sorted but large textural variations occur from bed to bed. Subangular erratic boulders (plutonics and greenstones) are common.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

The sequence of deposits exposed in the old hydraulic pit on lower Hixon Creek is typical of many late Quaternary successions in the region. Thick deposits of diamicton at the base of the section are interpreted as till and glacially derived debris-flow deposits. The overlying sands and gravels are interpreted as a glaciofluvial deposits. Inclusions of unconsolidated diamicton and fine sediments are probably rip-up clasts of previously deposited glacial and glaciolacustrine strata. The capping silt and clay unit in the area is interpreted as a glaciolacustrine deposit and indicates that ice damming occurred during deglaciation in the region.

The great thickness (15 metres) of the underlying sand and gravel sequence and its high topographic position suggests that it was deposited in an aggradational glaciofluvial system and probably does not contain significant quantities of gold. Coarse gravel beds within this sequence are probably lag gravels deposited at the end of erosional phases. Gold values would depend on the thickness and original gold content of the eroded deposits but, as the glaciofluvial gravels stratigraphically overlie till and are overlain by thick overburden, it is unlikely that they contain gold in economic concentrations. The original source of gold in the region is believed to be paleochannel gravels that stratigraphically underlie till. There is potential in the area for future discoveries of these paleochannel deposits but any gold-bearing strata are expected to be deeply buried in most areas.

Gravels exposed in small mining pits on low terraces in this area are interpreted to be Holocene fluvial gravels. Gold occurring within these gravels was probably concentrated since deglaciation by stream erosion of the thick sequence of Quaternary deposits that originally filled the stream valleys. Erratic boulders within the gravels are probably lag clasts remaining from erosion of glacial sediments. Some of the gold in these sediments presumably was also derived from interglacial and preglacial paleochannel gravels. Gold is probably most concentrated on basal unconformities over bedrock or over impermeable strata and in coarse gravel layers. The low topographic position of the terraces suggests that the gold-bearing gravels are entirely postglacial and not glaciofluvial in origin.

GOLDEN BENCH MINE (Location No. 51, Figure 11)

SITE DESCRIPTION

This site is located on a low terrace of the Cottonwood River approximately 6 kilometres northwest of Cottonwood. The terrace has supported a productive mining operation for many years and parts of the terrace have been dredged in the past. The operation exploits mainly surface gravels. Small, shallow exposures exhibit up to 2 metres of well-bedded, moderately sorted, well-imbricated, pebble gravel with few cobbles. Clasts are well rounded and dominantly quartzites. Gravel beds exhibit both horizontal bedding, planar crosssbedding and trough crossbedding. Lenses of trough crosslaminated sand are common within the gravels and the terrace sequence is commonly capped by 1 to 2 metres of laminated to massive fine sands. The depth to bedrock is unknown throughout most of the property but it is probably more than several metres. Gold at this site is recovered mainly from a coarse, crudely stratified gravel layer within the upper few metres from the surface. Gold content is apparently highest in the upper 2 metres. Most of the recovered gold is fine grained and flat but some nuggets are also found.

Two holes were drilled at the west end of the property in 1992 to investigate the possibility that older paleochannel deposits may exist in area (Levson *et al.*, 1993b). The holes were collared on opposite sides of a broad, low terrace on the south side of the river. The terrace is a few metres higher than the present channel and directly upstream from a bedrock-floored canyon into which the Cottonwood River valley narrows. High ridges on both sides of the canyon are comprised mainly of bedrock to the north of the river and unconsolidated Quaternary sediments to the south. Small bedrock knolls are also exposed at low water levels along the present course of the river upstream from the canyon. Gravels occur throughout the entire drilled sequence above bedrock which was intersected at a depth of about 20 metres in both holes. The gravels are gold bearing with the highest gold recovery occurring in coarse gravel beds at the bottom of the holes. Deep-channel gravels on the southwest side of the terrace have been mined at one site near the valley side. Mining was stopped when the gravels could no longer be removed because they were covered by, and apparently extended underneath, a thick clay (glaciolacustrine?) sequence.

Other properties in the area are also exploiting terrace gravels. Trenching on a similar, but higher, terrace upstream from this site exposed bedrock at a depth of 1 metre. Gravels over the bedrock are well rounded and sorted. Gold is recovered by careful cleaning of fractures in the bedrock surface.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

The mined gravels at this site are interpreted as fluvial deposits formed on a late Holocene terrace of the Cottonwood River. The terrace formed as the main river channel migrated back and forth across the valley; major channel shifts were probably associated with flood discharges. Evidence of recent channel shifts is apparent on aerial photographs of the site and includes a number of abandoned river channels now represented by oxbow lakes. The modern Cottonwood River channel is shallow and the depth of erosion in older channels was apparently comparable, explaining why gold is most concentrated in coarse gravels near the surface. Channels occupied by the river for relatively long periods of time probably contain more gold than shorter lived systems and, therefore, the best mining targets are channels that exhibit the highest degree of geomorphic development.

Trough crossbedded, horizontally bedded and planar crossbedded gravels are interpreted, respectively, as minor channel-fill sequences, longitudinal bars and transverse bars. Gold concentrations in these deposits are typically facies controlled with most gold occurring in lag gravels at the base of channel scours, in coarse gravel beds and along basal unconformities in bar sequences.

Most of the fine-grained gold in this area is probably derived from auriferous placers occurring upstream along Cottonwood River and Lightning Creek (Figure 11). John Boyd Creek joins the Cottonwood River just upstream from this site and placers in that drainage, such as those on Mary and Alice Creeks, probably also supply gold to this area. Most recovered gold particles are small, flat and well worn giving the impression of a relatively long distance of travel.

Some of the gold in the gravels may have originated in a large preglacial paleochannel of the Cottonwood River system that drained northwesterly into the paleovalley of the old Fraser River. Bedrock exposures in the modern channel of the Cottonwood River, particularly those along the canyon directly below the 1992 drill sites, constrain the depth of Holocene incision of the river to that of the present-day channel. Consequently, as bedrock is nearly 20 metres below the present channel base at the drill sites, the gravels in the lower part of the sequence must predate the Holocene. The gold-bearing coarse gravel beds at the bottom of the holes are interpreted to be erosional lag gravels of interglacial or preglacial age. They were deposited in a paleochannel that lies south of the present river and may extend under the thick Quaternary deposits south of the canyon. The placer operation at this site is evaluating the potential for mining these paleochannel gravels in areas where they may be preserved below Holocene terrace gravels. The results of drilling in the area suggest that evaluation of the more deeply buried gravels might be warranted (Levson *et al.*, 1993a). More emphasis will have to be placed on determining depth to bedrock in these buried gravel systems, if attempts to define the location of preserved paleochannel deposits in the region are to be successful.

LOWER SOVEREIGN CREEK AREA (Location No. 52, Figure 11)

SITE DESCRIPTION

A small mine has recently operated along the upslope edge of a small terrace paralleling Sovereign Creek, about 1 kilometre upstream from its confluence with the Swift River. Beds at the base of the exposed sequence are poorly sorted and consist of a mix of gravel and diamicton. Gold is reported to occur throughout the sequence in small quantities and the highest concentrations occur over bedrock.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

Although the operation at this site is targeting a possible buried channel that is believed to obliquely intersect the Sovereign Creek valley, the deposits exposed are interpreted as recent terrace gravels with interbedded debris-flow deposits. Well-imbricated and well-sorted cobble beds indicate fluvial deposition in a moderately high energy, stream environment probably similar to the modern stream. Horizontally laminated fine sediments capping the sequence are interpreted as overbank deposits. Intraclasts of diamicton and broken wood fragments in other beds reflect the input of debris flows from the valley side. Gold at the site is believed to have been reworked from upstream placers and transported to the site by fluvial processes.

Two holes were drilled along Sovereign Creek about 2 kilometres upstream from this property in 1992, in an area with excellent potential for a large-volume buried paleochannel placer deposit of interglacial or preglacial age. This deposit occurs in a buried valley, recently identified from satellite data (Reimchen, 1990), that apparently trends westerly parallel to Sovereign Creek. The paleovalley is separated from the modern Sovereign Creek valley by a bedrock high which has been exposed by recent mining and forms the northeast wall of the buried channel. Auriferous paleochannel gravels were intersected in the first hole, located about 500 metres south of the mine, at depths from 8 to 27 metres. They overlie bedrock and are overlain by diamicton units with interbedded silty clays interpreted as till and glaciolacustrine sediments, respectively. The second hole was drilled approximately 1.25 kilometres south of the mine to help define the extent of the paleovalley and its general orientation. Bedrock was encountered at shallower depths (16.5 metres), indicating that the paleochannel shallows to the south and the auriferous gravels thin substantially in that direction.

UPPER COTTONWOOD RIVER AREA (Location No. 53, Figure 11)

SITE DESCRIPTION

This site is located along the Cottonwood River approximately 2 kilometres southeast of Cottonwood. The section is a natural cutbank exposing sediments in a low terrace on the north side of the river. Terrace gravels and sands (Units 3 to 9, Section 9053, Appendix 2) exposed at this site unconformably overlie deformed clay, silt and sandy strata (Units 1 and 2) and are conformably overlain by horizontally laminated silts and fine sands (Unit 10).

GEOLOGICAL INTERPRETATION

The Cottonwood River has cut a channel into the sediments of a broad, postglacial, alluvial plain. The river is slowly eroding its channel and exposing a thick section of alluvial sediments. The sand and gravel deposits are interpreted as a meandering stream, channel-fill sequence. The lowermost sand and gravel beds (Units 3 to 5, Section 9053,

Appendix 2) contain numerous intraclasts of silt and fine sand derived from the underlying deposits and their lower contact is erosional and marked by a lag gravel. Beds dip northward and have the characteristics of epsilon crossbeds, typical of point bar deposits in meandering channels. The overall fining-upward sequence, coarsening of the deposits in the down-dip direction towards the channel centre and westerly paleoflow data at right angles to the dip direction of beds, are all suggestive of a meandering stream environment. Crude horizontal bedding and trough crossbedding in Units 8 and 9 are interpreted, respectively, as longitudinal bar and cut-and-fill deposits. Horizontally bedded silts and fine sands capping the sequence are inferred to be overbank deposits (Unit 10). Scroll bar deposits and abandoned channel cutoffs on the terrace surface further suggest deposition in a meandering stream.

Deformed clay, silt and sand beds underlying the terrace gravels (Unit 1, Section 9053, Appendix 2) are interpreted as glaciolacustrine sediments that have been tilted and sheared as a result of post-depositional slumping. They were probably deposited in an ice-dammed lake, with deformation resulting from melting of supporting ice blocks, possibly during deglaciation. A glaciotectonic origin for the deformation is also possible but less likely as the orientations of tilt (175°) and shear structures (245°) differ substantially from one another and from the regional ice-flow direction (350°) as indicated by well-developed flutings and drumlins in the area.

PLACER POTENTIAL

Potential for placer gold exists in most of the terrace deposits in this area but values will be sporadic owing to the facies-controlled nature of gold concentration. Coarse gravel beds overlying erosional unconformities at the base of and within the channel-fill sequences are expected to have the highest gold concentrations. The potential for gold generally increases with proximity to bedrock and with the coarseness of the gravelly strata. An evaluation of the paleostream profile may be possible in this area, by a detailed elevation survey of the basal gravel unconformity, with the intent of identifying sharp gradient changes where gold may have accumulated. Paleogeographic reconstruction of the alluvial plain from geomorphic and stratigraphic data may also help to identify specific sites with high placer potential, such as major abandoned channels.

COLDSPRING HOUSE AREA, LOWER LIGHTNING CREEK (Location No. 54, Figure 11)

SITE GEOLOGY

There are a number of small mining operations exploiting Holocene gravels on a series of low terraces along Lightning Creek, upstream from its confluence with the Swift River, west of Coldspring House. Most of the terrace surfaces in the area have been worked, indicating that gold is widely dispersed through the terrace gravels. In general, the mined sediments are characterized by horizontally stratified sands at the surface that overlie stratified gravel sequences. The latter commonly are red to purple in colour, indicating the presence of iron and manganese oxides.

Sands and gravels capping the highest terrace at Mexican Hill (Section 9054, Appendix 2) are inferred to be glaciofluvial terrace gravels. Thick, massive diamicton with striated clasts exposed at the base of the section is interpreted as a till deposit, probably Late Wisconsinan in age. A glaciofluvial origin for the upper gravels is indicated by the high level of the terrace and by the dominance of crude horizontal bedding typical of longitudinal bar deposition in aggrading braided streams. These valley-fill gravel and sand deposits probably contain little gold and they have not been extensively mined in the area. Erosion by Lightning Creek during the Holocene has resulted in channel incision into these older glacial and glaciofluvial sediments.

PLACER POTENTIAL AND GOLD SOURCES

A series of low terraces on the valley floor are believed to have a better placer potential than the upper terrace. The stratigraphic sequence in the low terraces is very similar to the upper part of exposures at Location 53 on the Cottonwood River. As the terrace suites are similar in elevation and can be traced laterally on airphotos between the two sites, it is probable that gold can be recovered from other terraces in the intervening area.

Gravels in the low terraces were presumably deposited during the Holocene and probably reconcentrated gold from the glacial and glaciofluvial sediments and possibly also from interglacial gravels upstream. Interglacial sediments deposited before 51 000 years B.P. and occurring between two drift sheets are known to be present in the Mexican Hill area (Clague *et al.*, 1990). Although it is not known if these deposits are auriferous, gold has been mined from gravels stratigraphically underlying till and glaciolacustrine sediments at a number of deposits upstream from this area (see Locations 24-26).

In general, gold recovered from mines in this area (Locations 24, 25, 26, 53, 54 and 55) becomes progressively coarser with distance up Lightning Creek and finer with distance downstream. This suggests that the gold in these placers was derived from sources near the uppermost sites (25 and 26). The Spanish and Eureka thrust faults cross the Lightning Creek valley in the vicinity of these locations (Figure 11) and are the most probable sources of gold in the area.

ROMANOW MINE, LIGHTNING CREEK (Location No. 55, Figure 11)

SITE DESCRIPTION

This site is located on a low terrace on the south side of Lightning Creek downstream from Wingdam (Location 55, Figures 3 and 10). Gravels have been mined from a bedrock gutter (small channel) that is separated from the modern Lightning Creek channel by a bedrock ridge. A second, stratigraphically higher, gold-bearing gravel locally overlies a silt layer in the upper part of the terrace sequence.

Recently recovered gold commonly occurs as 1 to 2-gram flakes and nuggets, the largest being approximately 15 grams, but nuggets up to 25 grams have been reported by previous miners. Gold-bearing gravels overlie bedrock and the best values come from deposits over weathered, soft argillite, phyllite or schist. Lower values are found in gravels overlying harder bedrock units such as quartzites.

GEOLOGICAL INTERPRETATION

The deposits mined at this site comprise a typical terrace-gravel sequence. Crudely stratified and imbricated, pebble to cobble gravels (Unit 1, Section 8955A; Units 1 to 3, Section 8955B, Appendix 2) overlying bedrock are interpreted as fluvial channel gravels and longitudinal bar deposits. Gravel imbrication measurements indicate paleoflow directions similar to the modern stream. Overlying fining-upward sequences of horizontally stratified sand and silt (Units 2 to 9, Section 8955A; Units 4 and 5, Section 8955B, Appendix 2) reflect sedimentation during decreasing flows and intermittent ponding prior to channel abandonment, as well as subsequent overbank sedimentation. Poorly sorted pebbly sands capping the exposures along the valley side (Unit 10, Section 8955A, Appendix 2) are interpreted as colluvial slope deposits.

PLACER POTENTIAL

Gold concentrations are highest in gravels overlying argillaceous bedrock and foliated rocks, presumably because quartzitic bedrock in the area generally has fewer bedding surfaces or erosional irregularities to act as gold traps. Stratigraphically higher silt and clay beds also act to trap gold and constitute a false bedrock. The auriferous gravels overlying these mud beds are young terrace deposits and they contain gold that presumably was reworked from paleochannel gravels by the Holocene Lightning Creek. Consequently, there is potential for the discovery of other stratigraphically equivalent auriferous gravels on low terraces both upstream and downstream from this site as well as paleochannel gravels at upstream sites.

The bedrock gutter mined along the south side of Lightning Creek may be one such paleochannel remnant. It extends along the terrace and rises to the west, eventually pinching out near the valley side. As the channel slopes in the opposite direction to the west-flowing Lightning Creek, it is possible that it is a paleotributary to Lightning Creek originating on the slopes to the south. A drilling program on the south valley side was conducted in the latter part of the 1990 season to test this possibility, but apparently no extensions of the deposit were found under till there.

SOMMERFELT MINE, QUESNEL RIVER (Location No. 56, Figure 12)

This small mine site is located on a low terrace on the south side of the Quesnel River, 5 kilometres upstream from the Buxton Creek road and Hydraulic road junction (Location 56, Figures 2 and 12). Two abandoned channels of the Quesnel River, each about 25 metres wide, occur on the surface of the terrace. Gold values are reported to be highest in cobble beds along the base of the channels. Beds dominated by pebble gravels are less productive. Recovered gold is mainly fine grained, averaging 1 to 2 millimetres but grains up to 1 centimetre in diameter occur. The gold is well flattened and is recovered with abundant black sand.

The gold-bearing gravels and sands exposed in the low terrace at this site are interpreted as braided stream deposits. Large, angular boulders at the base of the section indicate high-energy erosion of local bedrock during the early stages of terrace formation. Fining upward in the gravels from boulders and large cobbles at the base to coarse sands and granules at the top (Units 2 to 4, Section 9056, Appendix 2) probably reflects decreasing flows due to gradual infilling of the channels. Horizontally bedded gravels are probably longitudinal bar deposits and clast imbrication indicates paleoflow directions similar to the modern stream. Silts and clays (Unit 1) underlying gravels are interpreted as glaciolacustrine sediments that formed in a glacial lake ponded in this portion of the Quesnel River valley during deglaciation when ice dammed drainage to the west and south. Correlative glaciolacustrine sediments, deposited at the end of the last glaciation, occur at a few other sites in the Cariboo and Quesnel River valleys (Clague, 1991).

QUESNEL FORKS AREA (Location No. 57, Figure 12)

This site is located at Quesnel Forks on a low terrace 10 to 15 metres above the level of the Cariboo River, approximately 500 metres upstream from the confluence of the Quesnel and Cariboo rivers. Other operations in the area are mining similar low-terrace gravels, including a large mine on the opposite (northwest) side of the Quesnel River. Fine gold is found in the entire exposed gravel sequence and is reported to occur in higher concentrations in the uppermost units.

Gravels exposed at this site are generally well sorted and well stratified. They are interpreted as braided stream deposits. This interpretation is supported by evidence of multiple channel features on terrace surfaces in the area. The gravels exhibit mainly horizontal bedding indicating deposition in longitudinal bars. Channel scours with coarse gravel lags are locally common. Deposition in transverse and linguoid bars is also indicated by the presence of planar and trough crossbedded gravel beds, respectively.

The location of this deposit at the confluence of two major streams may explain its productivity as relatively high flows at converging channels commonly allow for increased deposition of gold (Mosley and Schumm, 1977; Smith and Minter, 1980). Other low terraces in the area may also be economic. Detailed geomorphic mapping of the terraces may help identify abandoned channel courses and sites of potential gold enrichment such as former channel junctions. Beds dominated by coarse gravels with open-work frameworks along erosional unconformities (channel scours) are considered to be the best targets for gold concentrations.

POSTGLACIAL COLLUVIAL AND ALLUVIAL FAN DEPOSITS (Locations 58 to 61)

SLOUGH CREEK MINE (Point Bench) (Location No. 58, Figure 7)

SITE DESCRIPTION

This site is located along Slough Creek downstream from its confluence with Devils Lake Creek. The area was the focus of a large hydraulic operation supplied by a ditch system (Hong's ditch) that follows the contour on the northeast slope of Mount Nelson and crosses Devils Lake Creek canyon via a wooden trestle flume. The slopes below the level of the ditch were hydraulically mined to bedrock in many areas and tailings fans now cover most of the lower slopes. The hydraulic operations exposed a series of flat rock benches paralleling Slough Creek that are locally cut by small channels trending downslope across the benches. The upper benches were not hydraulically mined above the level of the ditch. Large, branching, quartz veins up to a metre wide can be seen in outcrops along the lower slopes of Mount Nelson. The veins are locally pyritic and they generally trend northerly.

Recently mined sediments include small gravel deposits preserved near the upper limits of former hydraulic operations and remnant terrace gravels near the old camp in the Slough Creek valley that were not mined either because of buildings on the site or low gold concentrations. The low-terrace gravels are imbricated and horizontally bedded (*e.g.*, Section 9058B, Appendix 2) but they have not been tested extensively. Remnant gravel deposits on the lower slopes of Mount Nelson are thin, discontinuous and commonly overlain by tailings. One small test pit at the level of Hong's ditch exposes 2 to 3 metres of auriferous, crudely stratified gravels with a sandy silt matrix and numerous locally derived angular clasts (Section 9058A, Appendix 2). The depth to bedrock at the pit location is unknown. Gold grains up to about 15 grams have been recovered from the remnant gravel deposits on Mount Nelson.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

Mined auriferous gravels on Mount Nelson are well rounded, clast supported with a laminated fine-sand matrix, and fill small elongated depressions in the bedrock. They are interpreted as fluvial gravels deposited in small channels trending more or less perpendicular to the Slough Creek valley. Diamicton overlying the gravels is probably colluvial in origin as indicated by the presence of crude stratification, poor sorting and the incorporation of both well-rounded (fluvial) and striated (glacial) clasts. Bedrock at the mine site has proven to be an excellent trap for gold because it has natural riffles and is easily broken. The deposits are considered to be remnants of the original surficial cover on Mount Nelson, missed by hydraulic mining.

Low-terrace gravels exposed in the Slough Creek valley have characteristics typical of postglacial braided stream deposits (Section 9058B, Appendix 2). They are dominated by weakly imbricated, coarse gravels with crude horizontal bedding consisting of alternating matrix-filled and openwork beds interpreted as longitudinal bar deposits. Poorly sorted bouldery gravel beds fine upwards into better sorted pebble gravels reflecting deposition from high-energy discharges and their subsequent waning flows. Coarse bar-head gravels and openwork gravel beds around large boulders are potential sites for placer gold accumulation.

Gold recovered from previous hydraulic operations in this area was found mainly in sub-till gravels overlying the bedrock benches, in cross-channels and locally in oxidized, partially cemented, interglacial gravels found between two till sheets (Johnston and Uglow, 1926). Some of the higher benches were found to slope upstream and were believed to have formed in preglacial time when the drainage system was substantially different from today. Gold was probably incorporated from the older gravels into the till of over-riding glaciers and was subsequently reconcentrated by postglacial streams to form the gold-bearing surface gravels that are now being mined in the area. Gold recovery from these remnant gravel deposits has been sporadic. Good exposures of till and subglacial gravels, as described by Johnston and Uglow (1926), are lacking.

Potential for the discovery of new paleochannel gravels in this area is highest near or above the level of old hydraulic operations. Holocene terrace gravels in the valley bottom also have potential, but most deposits below the old hydraulic ditch have either been mined out or are covered by variable thicknesses of tailings. Low-terrace gravels near the old camp deserve further investigation. In addition, productive interglacial or preglacial deposits may be present in the valley bottom. As depths of burial by Holocene alluvium are probably lowest along the valley sides, exploration may be most successful there.

DEVLIN'S BENCH, WILLIAMS CREEK; (Location No. 59, Figure 7)

SITE DESCRIPTION

This site is located on a sloping bedrock bench (Devlin's bench) on the north side of Williams Creek, north of the Wells airstrip. Tailings from a large dredge pond on Williams Creek Flats adjacent to the site were deposited on this bench and comprise a sandy diamicton in the upper part of the mined sequence (Figure 34A). Recent operations removed old tailings and overburden on the bench and mined down to bedrock. The old Williams Creek channel is water-filled but is reported to be more than 10 metres deep in this area and has been excavated to bedrock. There are mining plans to drain the channel and work along the southern edge. The base of the channel to the east is reportedly muddy and unworkable. Recovered gold is relatively coarse, rounded and flattened, nuggets are commonly 2 to 3 grams and up to 10 grams. There is very little fine gold.

GEOLOGICAL INTERPRETATION

Although the mined deposits at this site are capped by old dredge tailings, the lowest exposed gravels (Figure 34A, Units 1-3, Section 9059, Appendix 2) appear to be original, thin, fluvial deposits interbedded with locally derived colluvium built along the lower slopes of Valley Mountain adjacent to Williams Creek. Poor sorting, chaotic fabrics and numerous angular local clasts in coarse gravel beds are indicative of debris-flow deposits whereas moderately sorted pebble gravel beds with numerous, well-rounded clasts and some openwork lenses are interpreted as fluvial gravels deposited by slopewash processes in rills and small gullies.

PLACER POTENTIAL

The lower slopes of Valley Mountain have good potential for colluvial placers because of the proximity of highly auriferous paleostream placers in the area from which gold may have been recycled. For example, northward flowing glaciers may have eroded gold from the rich stream placers in the upper Williams Creek valley and redeposited it where the valley widens at the base of Valley Mountain. Slope processes may have subsequently reconcentrated the gold from the till into the surface colluvial deposits. The lower slopes of other mountains in this area probably also have potential for colluvial placers, particularly where slope drainage is most concentrated. In addition, there is good potential for the discovery of paleochannel deposits in the valley bottom, such as those worked by the former dredging operation in the area. Down-valley extensions of the Williams Creek paleostream placers certainly existed but their extent and degree of preservation from glacial erosion have not been well investigated.

BIG VALLEY CREEK (Location No. 60, Figure 6)

SITE DESCRIPTION

This site is located on the south side of Big Valley Creek. The deposits in a small draw along the valley side were previously hydraulically mined. Gold has recently been recovered from a small open pit at the base of the old hydraulic mine. Coarse gold (1 - 5 millimetres in diameter) also occurs in the upper few metres of surface gravels on the valley slope and is recovered from moss mats.

GEOLOGICAL INTERPRETATION

Old hydraulic mining at this site has exposed nearly 10 metres of poorly sorted, crudely bedded gravels and diamicton (Section 9060A, Appendix 2). They are interpreted as colluvial deposits formed by debris-flow events that probably occurred in paraglacial times before slopes were stabilized by vegetation. The deposits are similar to alluvial fan sediments but there is no pronounced fan morphology due to the absence of a well-developed fan-head channel.

Gravels exposed in a small terrace along the south side of valley bottom (Unit 1, Section 9060B, Appendix 2) are moderately well sorted, well rounded to subrounded, moderately well stratified and contain numerous stratified sand lenses. They are interpreted as fluvial gravels deposited by an early postglacial phase of Big Valley Creek. They are covered by tailings from the hydraulic mine (Unit 2).

PLACER POTENTIAL

Continued mining of the deposits exposed at Section 9060A will probably yield similar results to previous operations, however the cost of overburden removal restricts the mining of these more deeply buried sediments. The possibility of paleogulch channel deposits along the slopes of Big Valley between this site and Eight Mile Lake (Figure 7) is good as the area is underlain by the potentially auriferous rocks of the Downey succession. However, directly downstream from this site, Big Valley Creek crosses the Pleasant Valley thrust into the rocks of the Cariboo Terrane. Potential placer deposits there are probably restricted to fluvial terraces with gold values generally expected to diminish downstream.

The potential for gold recovery in terrace gravels at this and nearby sites is good and attempts to reach pay streaks over bedrock may prove to be particularly productive. The discovery of well-rounded gravels, reported to be more than 5 metres thick and with clasts up to large-boulder size, above this site (approximately 70 metres above the valley bottom) was thought to be an indication of a possible buried paleochannel (A. Bolduc, personal communication, 1990). However, a glaciofluvial origin for these gravels is considered more likely. The latter interpretation is supported by the presence of small esker-like ridges in the area.

NELSON CREEK MINE (Location No. 61, Figure 7)

SITE DESCRIPTION

This site is located on the east side of Nelson Creek. The area has been the focus of mining operations for many years. Remnants of one or possibly two paleochannels on both sides of Nelson Creek were mined hydraulically in the past. The present mine exploits surface deposits mainly in the upper few metres with a maximum mining depth of about 8 metres. The gold content is reported to be 0.1 to 0.4 gram per cubic metre in the upper 2 metres and 1 to 1.5 gram per cubic metre in the lower 3 metres.

The site is located close to the western edge of an old hydraulic pit (Hong's pit). The pit follows a narrow bedrock gully that trends southwesterly up the side of Nelson Mountain, oblique to the modern Nelson Creek channel. Bedrock exposed at the base of Section 9061A forms the west rim of the gully. Exposures farther upslope, in an active part of the mine site along a highwall parallel to Nelson Creek (Section 9061B, Appendix 2), reveal gravels overlain by laminated silts and massive diamicton.

GEOLOGICAL INTERPRETATION AND PLACER POTENTIAL

Massive, matrix-supported diamictons and interbedded gravels overlying bedrock at this site (Figure 34B; Section 9061A, Appendix 2) are interpreted as postglacial colluvium and alluvium deposited along the lower slopes of Mount Nelson. Diamicton beds have characteristics typical of debris-flow deposits including numerous angular clasts of local bedrock with crude imbrication indicating paleoflows toward the northeast (downslope). Interbedded sand and gravel lenses are interpreted as intermittent alluvial channel deposits. The origin of the gold in this deposit is local, probably eroded from bedrock and older placer deposits farther up the mountain and reconcentrated by slope processes.

At Section 9061B, the basal gravels (Units 1 and 2) carry the highest gold values and are interpreted to be fluvial deposits with some debris-flow sedimentation, as indicated by poorly sorted beds with normal grading, poor imbrication and angular clasts of local bedrock. Overlying laminated silts, clays and fine sands are interpreted as glaciolacustrine sediments deposited when an ice-dammed lake formed in the Slough Creek valley during the advance phase of the last glaciation. The uppermost deposit at the site is a matrix-supported diamicton containing numerous striated clasts and is inferred to be a till deposited during the last glaciation. The till has locally been resedimented by slope processes.

The presence of mineable gold concentrations in surface colluvial and alluvial deposits in this area, and the extent of old bedrock channel workings, suggests that there is potential for the discovery of new auriferous deposits. Potential paleochannel gravels up-valley from Hong's hydraulic pit, for example, have not been mined. Fine-grained glaciolacustrine deposits overlying the older gravels probably inhibited glacial erosion and as the older gravels are preserved on the valley slopes it is probable that they were not eroded from more protected bedrock channels. As a similar stratigraphic situation is expected elsewhere in the Slough Creek valley, there is also potential for the discovery of paleochannel deposits along other tributary streams in the region like Nelson Creek.

CHAPTER 6 PLACER DEPOSITS IN GLACIATED AREAS - EXPLORATION AND MINING

Placer mining continues to be active in many glaciated areas, even in heavily explored, traditional gold mining regions, indicating that the potential for the existence of new, unexploited deposits is good. Reasons for this probably include both the difficulty of locating these placer deposits as well as the increased expense of mining these deposits once discovered, due to high overburden removal costs. Many paleochannel placer deposits are entirely buried by glacial sediments and they have little or no topographic expression or relationship to modern stream channels. However, exploration and mining costs in many deeply buried deposits can be offset by their typically high gold contents (Bliss *et al.*, 1987; Levson, 1992a). In addition, the depletion of shallow, easily mined placers and the trend towards increased exploitation of buried gravels in glaciated areas, requires an increased reliance on geologic information to locate new reserves and to evaluate exploration targets (Armstrong, 1983; Levson and Morison, in press). Although, in the past, the search for these deposits has focused on historically active areas, mainly utilizing simplified stratigraphic data gleaned from mining and anecdotal records, exploration companies now are collecting more diverse geologic information, from near mined areas as well as in relatively unexplored regions.

A brief discussion of some of the geologic factors relevant to exploration and mining of placer deposits in glaciated areas is provided in this chapter. However, a comprehensive description of all the different methods of locating, evaluating and mining placer deposits is beyond the scope of this report. More complete discussions of placer exploration and mining techniques have been provided by the British Columbia and Yukon Chamber of Mines (1981) and Hilchey (1990). An excellent report on gold recovery was presented by Clarkson (1991) and a discussion of operational parameters, basic principles and methods of estimating capital and operating costs of different placer mining techniques was provided by Stebbins (1987).

EXPLORATION METHODS

Modern placer exploration programs should incorporate sedimentologic, stratigraphic and geomorphologic studies with methodologies involving different levels of mapping. The latter include small-scale regional surveys using satellite imagery, larger scale geomorphological mapping from airphotos, and detailed field surveys for ground checking and collection of geologic data (Teeuw *et al.*, 1991). In addition, exploration activities, particularly those designed to locate and test buried placers, should focus on subsurface techniques such as geophysical programs, including seismic reflection and refraction and ground-penetrating radar surveys, and follow-up drilling. Numerous fluvial channels, buried beneath as much as 100 metres of glaciolacustrine sediments and till, have been detected by seismic refraction methods and drilling along several rivers in the Beauceville placer area of southern Quebec (Shilts and Smith, 1986). Other techniques such as electromagnetic, resistivity and induced polarization surveys are useful in some geologic settings although their applications to placer exploration have not been well studied (Armstrong, 1983). Information on these techniques can be found in standard geophysical reference texts.

The usefulness of a variety of different subsurface exploration techniques, used in conjunction with geologic models compiled from stratigraphic, sedimentologic and geomorphic data, was recently demonstrated by Levson *et al.*, (1993a, b) in the Cariboo. A number of new auriferous buried-channel deposits were identified and investigated using reverse-circulation drilling, borehole logging (measuring apparent conductivity, naturally occurring gamma radiation and magnetic susceptibility), ground-penetrating radar surveys and industry seismic survey data. As has also been shown in other areas (*e.g.*, Smith and Jol, 1992), ground-penetrating radar is a particularly useful tool for locating channels and other sedimentary structures in sand and gravel deposits, provided they are not overlain by clay-rich sediments. In order to locate and identify the extent, volume and overburden thickness of deeply buried, gold-bearing strata in relatively unexplored areas, data obtained by these subsurface methods should be combined with regional stratigraphic and detailed sedimentologic information collected along natural exposures and in any nearby areas of active mining. Exploration activities should also include regional airphoto interpretation components to reconstruct the preglacial and glacial history and to search for any geomorphic indicators of paleochannels. This database can then be used to reconstruct the paleogeography and help define regional drainage patterns of Late Tertiary and Quaternary rivers and thereby identify probable locations of buried gold-bearing channels. Narrow channels oriented oblique to glacier flow, supporting thin overburden, are the best targets. The identification and testing of these channels should be a major focus for placer exploration.

Another simple exploration methodology for locating deeply buried placer deposits, that may have been under estimated in the past, is the use of meltwater channels and other valleys where the overburden has been removed by natural processes. Initial concentration of exploration and

TABLE 1

SEDIMENTARY CHARACTERISTICS RELEVANT TO EXPLORATION, MINING AND PROCESSING	COMMON PRODUCTION METHODS
TERTIARY AND PRE-LATE WISCONSINAN PLEISTOCENE PLACERS	
- thick unconsolidated Quaternary overburden typical - Tertiary placers commonly cemented - interglacial placers often over consolidated - auriferous strata generally laterally discontinuous due to variations in erosion and preservation - clay-rich, compact till or glacial lake deposits often interbedded with pay zones in interglacial deposits	-underground mining common especially in Tertiary deposits - interglacial placers often open-pit mined especially in meltwater channel and leeside settings - disaggregation systems needed
Paleochannel Settings - excessive overburden in abandoned trunk valleys - lack of surface water in topographically high paleovalleys - excess groundwater and surface-water problems in buried channels within modern valleys - auriferous gravels often interbedded with barren colluvial deposits in narrow paleochannel settings - poor sorting and abundant cobble and boulder-sized clasts in paleogulch settings	- hydraulic mining (formerly) and large open-pit operations - water pumping or recycling often required - specialized excavating equipment, explosives and screening equipment needed in paleogulch settings
Buried Alluvial Fan Settings - textural diversity - interbedded fine-grained and poorly sorted deposits - lower grade than fluvial placers	- large-volume open-pit mines - jig-trommel-sluice processing systems
LATE WISCONSINAN PLACERS	
Glacial Deposits - usually over consolidated with high clay contents - large boulders often present - low grade and uncommon except down valley from pre-existing high-grade deposits	- specialized disaggregation and pre-screening equipment - open-pit mines
Glaciofluvial Deposits - often low grade but large volume - large boulders and poorly sorted strata common - common in high terraces lacking surface water	- large-volume open-pit mines - dredging operations - pre-screening equipment
HOLOCENE PLACERS	
Fluvial Deposits - mainly fine gold (< 1 mm) in downstream locations - silty overburden and abundant organics	- floating dredge or shovel systems
Colluvial Deposits - thin (< 2 m) and localized pay zones	- shallow open-pit mines - portable processing plants

mining activities on sites where these valleys may coincide with ancient gold-bearing drainage courses, has proven to be a cost-effective means of locating and mining buried placers in some areas. For example, the Toop Nugget mine (Location 15) was discovered in 1972 in a meltwater channel from which at least 20 metres of overburden had been removed by glaciofluvial erosion. In contrast, correlative gold-bearing gravels at the nearby Alice Creek mine (Location 14) are overlain by about 30 metres of overburden.

GEOLOGIC CONTROLS ON EXPLORATION AND MINING

The sedimentologic, geomorphic and stratigraphic characteristics of different types of placers directly affect mining practices. Table 1 outlines the main sedimentary characteristics of placers in different geologic settings that are relevant to exploration, evaluation and production in glaciated terrains. The geologic controls these characteristics impose on exploration and mining were discussed by Levson (1991a) and are summarized here for each of the main placer settings.

BURIED TERTIARY AND PLEISTOCENE DEPOSITS

Unlike many buried Pleistocene placers, Tertiary gravels are commonly strongly cemented with iron and manganese oxides or calcite and are therefore more readily mined by underground methods. However, due to strong cementation, it is often necessary to crush the pay gravel prior to processing. Because the added cost of crushing and processing may be prohibitive, indurated Tertiary gravels are not mined at many locations. In addition, paleocurrent and lithologic provenance data commonly indicate substantially different drainage patterns in the Tertiary than the present and, consequently, detailed geologic data are often needed to locate and trace gold-bearing formations.

Post-depositional over consolidation of interglacial placer deposits, due to the weight of over-riding glaciers, may be conducive to underground mining in some areas, especially where the deposits are of sufficient grade. However, due to poor lithification of the overburden in many areas, most are mined by open-pit methods. In addition, in open-pit mines, over consolidation of the gravels makes them more difficult to mine and process. Over consolidation and a silty matrix in some interglacial gravels inhibit effective sluicing and good washing and disaggregation systems are needed. Large-volume, buried, interglacial, fluvial placers have traditionally been hydraulically mined but due to environmental concerns this mining method has been discontinued. Due to excessive overburden removal costs open-pit mines are sometimes limited to the parts of properties where there has been at least some natural overburden removal by meltwater or postglacial fluvial erosion.

Auriferous formations in most placer deposits predating the last glaciation are discontinuous due to glacial and postglacial erosion. Erosion by interglacial streams and possible disruption by faulting also cause segmentation, particularly of the older deposits. Protection from glacial erosion is most common in leeside settings such as down-ice of large bedrock highs or in valleys oriented transversely to regional ice-flow direction. Because many Tertiary and early Pleistocene river systems were areally extensive and contained significant gold concentrations, further exploration for remnants of these paleochannel deposits is warranted in some areas. In addition, gold is often reconcentrated into younger fluvial deposits that unconformably overlie Tertiary or interglacial gravels, making them more attractive mining prospects.

Tertiary and interglacial auriferous strata commonly are interbedded with fine-grained lacustrine, glaciolacustrine and sometimes marine strata. High gold concentrations are common in beds that directly overlie clay-rich sediments, probably because the clays inhibit erosion and act as a trap for gold particles. In the Horsefly area, for example, the Tertiary gold-bearing gravels directly overlie Eocene silts and clays, and elsewhere in the Cariboo, fluvial gravel units of both interglacial and postglacial age commonly overlie clay-rich glaciolacustrine sediments. At many mine sites, clay beds can be used as an indicator of possible overlying gold-bearing units as well as a stratigraphic marker for following the most auriferous strata (Pizzey, 1991). Although clay-rich beds create a suitable substrate for gold accumulation (commonly referred to as false bedrock), they also create processing problems, as it is difficult to separate gold from clays once they are mixed. Washing compact or clay-rich materials usually requires mechanisms for disaggregation prior to sluicing, such as trommel and spray systems.

PALEOCHANNEL SETTINGS

Thick overburden, typically tens of metres thick, is the main obstacle to locating, evaluating and mining Tertiary and interglacial Pleistocene paleochannel placer deposits. Detailed seismic cross-sections, drilling data and other subsurface information are required to evaluate paleochannel placers. Stratigraphic and sedimentologic data required to trace gold-bearing units includes information on thickness, depth and geometry of strata, paleochannel orientation and paleoflow direction.

The overburden sequence in paleochannel deposits commonly includes compact till, that is difficult to strip in open-pit mines, as well as clay-rich glaciolacustrine sediments that are also difficult to remove and create caving problems in both underground and open-pit mines. Thick overburden in many buried river-valley systems also obscures the gold-bearing paleochannel deposits, making them difficult to locate. Paleochannel placers buried below modern alluvium have the additional mining problem of surface and ground water drainage; whereas processing topographically high, buried-channel placers can be hindered by shortages of water needed for processing. Mines in the latter sites may need to operate on recycled rainwater and snow melt captured in ponds. These problems are somewhat offset by the potential richness and large volume of paleovalley placers.

Although smaller than buried braided stream and wandering gravel-bed river valley placers, single-channel, bedrock-floored placer deposits commonly contain significantly higher gold concentrations. The latter, particularly high-gradient paleogulch channel gravels, have historically been the richest gold producers in glaciated areas but these deposits are both difficult to locate and to mine because of thick glacial overburden and abundant large clasts. However, once identified, bedrock-floored single-channel placers tend to be easier to follow than the larger buried river-valley placers. Gold concentrations in the former tend to be concentrated in a relatively continuous and narrow zone at the channel base or gutter, whereas in large river channels, auriferous strata occur in broader zones, sometimes in multiple or stacked horizons that may be laterally disconnected and are not necessarily in the lowest parts of the gravel sequence. In some deposits where the paystreaks are thin or discontinuous it is sometimes necessary to process substantial amounts of barren sediments with the pay gravels.

Many paleogulch placers were mined hydraulically in the past and modern workings commonly are either above the upper elevation reached by the hydraulic operations or along the valley sides where remnants of buried pay gravels are preserved and are consequently small in size. The abundance and large size of clasts in buried gulch gravels and overlying colluvial deposits has a major influence on mining operations and sometimes requires specialized excavating equipment, explosives and pre-sizing before processing. At some paleogulch placer mines the overburden has been partially excavated by Holocene stream erosion.

PALEOALLUVIAL FAN SETTINGS

Alluvial fan deposits predating the last glaciation support large-volume open-pit mines but generally have lower grades than fluvially deposited placers of similar age. The gold in alluvial fan and fan-delta deposits also tends to be finer grained and more dispersed throughout the sediments. As gold occurs in thinly interbedded poorly sorted debris-flow deposits and better sorted fluvial gravel and sands, complex processing plants are needed. Combined jig-trommel-sluice processing systems able to disaggregate consolidated interglacial deposits, handle large volumes and recover fine gold are often required. The large volume and relatively uniform grade of these placer deposits makes them well suited for open-pit operations.

NEAR-SURFACE PLACERS

Most near-surface placers are postglacial in age and are mined in open pits. They occur in a variety of depositional environments. All of these deposits have the advantage of minimal overburden but they are generally lower grade than more ancient placers formed over longer periods of time. Postglacial gulch gravels were the most productive, accessible and easily mined of all the Cariboo placers and few survived beyond the turn of the century. Floodplain and low-terrace deposits were also largely mined out in the 1800s. However, fine gold carried many kilometres downstream from the original source area is still mined in some areas. In addition, higher terrace gravels can be locally productive. Glacial, glaciofluvial and postglacial colluvial and alluvial fan placers are also mined locally. However, most glacial, glaciofluvial and colluvial processes spatially (vertically and horizontally) disperse and sedimentologically alter pre-existing gold concentrations. The resultant stratigraphically and geomorphologically complex distribution and sedimentologic variability of these deposits creates numerous exploration, evaluation and mining problems.

Placers occurring in sediments deposited directly by glacial ice or by meltwater flowing near glaciers are mined only in a few areas. Over consolidation, high clay contents and large boulders in gold-bearing tills make mining difficult and modified plants are required to process the deposits. Tailings piles at operations mining tills commonly contain numerous intact diamicton blocks attesting to their resistance to disaggregation. These factors combined with generally low grades have prohibited mining of till in almost all areas. Glaciofluvial placers tend to be low grade and often contain large boulders and poorly sorted deposits inhibiting mining and processing. In high-terrace settings they form large-volume placer deposits with low gold concentrations. Large-capacity mining operations and processing plants are therefore required and mines exploiting these placers often experience water shortages due to their topographic setting.

Low-terrace placer deposits are easily mined and, in the upper reaches of many Cariboo streams where they contain relatively coarse gold, they have been depleted by historical mining. Mining activities in finer gold placers farther downstream are limited by the efficiency of fine gold recovery and the ability of the miner to locate sedimentary environments and specific facies where fine gold is concentrated. In addition, overbank fines and abundant organics, typical of these placers, can be a hindrance to mining and processing. Low-terrace placer deposits invariably have more than enough water to supply processing plants and, due to typically shallow water tables, they can be mined effectively with floating dredge or shovel systems with efficient rear tailings conveyors and sluice boxes.

Postglacial alluvial fan placer deposits are of significant volume and have the added advantage of minimal overburden. They can be efficiently mined by bulldozing directly into a 'cat-trap' at the head of a trommel-sluice processing system as at the Nelson Creek mine (Location 61). Although colluvial placers are commonly less than a few metres thick they also can be mined with innovative mining techniques such as easily portable processing plants.

REFERENCES

Alldrick, D.J. (1983): The Mosquito Creek Mine, Cariboo Gold Belt, 93H/4; *in* Geological Fieldwork 1982, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1983-1, pages 99 - 112.

Anonymous (1903): Horsefly Hydraulic Mining Company; 1902 Report of the Minister of Mines, *B.C. Ministry of Energy, Mines and Petroleum Resources*, pages H73-H75.

Armstrong E.J. (1983): Placer Gold Exploration; *in* Alaskan Placer Mining, Campbell, B.W., Madonna, J. and Husted, M.S., Editors, *University of Alaska*, Mineral Industry Research Laboratory Report Number 68, pages 48-49.

Ash, C.H. and Arksey, R.L. (1990): The Listwanite - Lode Gold Association in British Columbia; *in* Geological Fieldwork 1989, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1990-1, pages 359-364.

Bailey, D.G. (1989): Geology of the Swift River Map Area, NTS 93A/12, NTS 93A/13, 93B/16, 93G/1; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-20, 1:50 000.

Bailey, D.G. (1990): Geology of the Central Quesnel Belt, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-31, 1:100 000.

Barker, J., Robinson, M.S. and Bundtzen, T.K. (1989): Marine Placer Development and Opportunities in Alaska; *Mining Engineering*, Volume 42, pages 551-558.

Barlee, N.L. (1977): Historic Treasures and Lost Mines of British Columbia; *Canada West Publications*, 128 pages.

Best, J.L. and Brayshaw, A. (1985): Flow Separation - a Physical Process for the Concentration of Heavy Minerals within Alluvial Channels; *Journal of the Geological Society of London*, Volume 142, pages 747-755.

Bliss, J.D., Orris, G.J. and Menzie, W.D. (1987): Changes in Grade, Volume and Contained Gold During the Mining Life-cycle of Gold Placer Deposits; *The Canadian Mining and Metallurgical Bulletin*, Volume 80, Number 903, pages 75-80.

Bloodgood, M.A. (1988) Geology of the Quesnel Terrane in the Spanish Lake Area, Central British Columbia, 93A/11; *in* Geological Fieldwork 1987, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1988-1, pages 139-145.

Boyle, R.W. (1979): The Geochemistry of Gold and its Deposits; *Geological Survey of Canada*, Bulletin 280, 584 pages.

Boyle, R.W. and Gleeson, C.F. (1972) Gold in the Heavy Mineral Concentrates of Stream Sediments, Keno Hill Area, Yukon Territory; *Geological Survey of Canada*, Paper 71-51, 8 pages.

Bowman, A. (1895): Maps of the Principal Auriferous Creeks in the Cariboo Mining District, British Columbia; *Geological Survey of Canada*, Maps 364 to 372.

Brayshaw, A.C. (1984): Characteristics and Origins of Cluster Bedforms in Coarse-grained Alluvial Channels; *in* Sedimentology of Gravels and Conglomerates, Koster, E.H. and Steel, R.J., Editors, *Canadian Society of Petroleum Geologists*, Memoir 10, pages 77-85.

Bressler, J.R., Jones, W. and Cleveland, G. (1985): Geology of a Buried Channel System at the Denali Placer Gold Mine; *The Alaska Miner*, Volume 13, page 9.

British Columbia Department of Mines (1946): Notes on Placer Mining in British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 21.

British Columbia and Yukon Chamber of Mines (1981): An Introduction to Placer History, Minerals, Geology, Prospecting, Operating Methods, Law and Regulations; Short Course Notes, *British Columbia and Yukon Chamber of Mines*, Placer Mining School, 1981, 117 pages.

Buck, S.G. and Minter, W.E.L. (1985): Placer Formation by Fluvial Degradation of an Alluvial Fan Sequence: The Proterozoic Carbon Leader Placer, Witwatersrand Supergroup, South Africa; *Journal of the Geological Society of London*, Volume 142, pages 757 - 764.

Bull, W.B. (1972): Recognition of Alluvial Fan Deposits in the Stratigraphic Record; *in* Recognition of Ancient Sedimentary Environments, Rigby, J. K. and Hamblin, W.K., Editors, *Society of Economic Paleontologists and Mineralogists*, Special Publication 16, pages 63-83.

Bundtzen, T.K. (1986): Placer Geology of the Porcupine Mining District, Skagway B-4 Quadrangle, Alaska; *Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys*, Public-data File 86-27, 26 pages.

Bundtzen, T.K. (1991): Comparison of Placer and Lode Deposits of Central and Western Alaska with Northeast U.S.S.R.; Abstract, *Canadian Institute of Mining*, 1 page.

Burgisser, H.M. (1984): A Unique Mass Flow Marker Bed in a Miocene Stream Flow Molasse Sequence, Switzerland; *in* Sedimentology of Gravels and Conglomerates, Koster, E. H. and Steel, R.J., Editors, *Canadian Society of Petroleum Geologists*, Memoir 10, pages 147-163.

Campbell, R.B. (1978): Quesnel Lake 93A Map Area; *Geological Survey of Canada*, Open File 574.

Campbell, R.B., Mountjoy, E.W. and Young, F.G. (1973): Geology of the McBride Map Area, British Columbia; *Geological Survey of Canada*, Paper 72-35, 104 pages.

Church, M. A. (1983): Pattern of Instability in a Wandering Gravel Bed Channel; *in* Modern and Ancient Fluvial Systems, Collinson, J.D. and Lewin, J., Editors, *International Association of Sedimentologists*, Special Publication 6, pages 169-180.

Church, M.A. and Gilbert, R. (1975): Proglacial Fluvial and Lacustrine Environments; *in* Glaciofluvial and Glaciolacustrine Sedimentation, Jopling, A.V. and McDonald, B.C., Editors, *Society of Economic Paleontologists and Mineralogists*, Special Publication 23, pages 22-100.

Clague, J.J. (1987a): Quaternary History and Stratigraphy, Williams Lake, British Columbia; *Canadian Journal of Earth Sciences*, Volume 24, pages 147-158.

Clague, J.J. (1987b): A Placer Exploration Target in the Cariboo District, British Columbia; *in* Current Research, Part A, *Geological Survey of Canada*, Paper 87-1A, pages 177-180.

Clague, J. J. (1988): Quaternary Stratigraphy and History, Quesnel, British Columbia; *Geographie Physique et Quaternaire,* Volume 42, Number 3, pages 279-288.

Clague, J. J. (1989a): Gold in the Cariboo District, British Columbia; *Mining Review*, September/October, pages 26-32.

Clague, J.J. (1989b): Placer Gold in the Cariboo District, British Columbia; *in* Current Research, Part E, *Geological Survey of Canada,* Paper 89-1E, pages 243-250.

Clague, J. J. (1991): Quaternary Stratigraphy and History of Quesnel and Cariboo River Valleys, British Columbia: Implications for Placer Gold Production; *in* Current Research, Part A, *Geological Survey of Canada,* Paper 91-1A, pages 1-5.

Clague, J.J., Hebda, R.J. and Mathewes, R.W. (1990): Stratigraphy and Paleoecology of Pleistocene Interstadial Sediments, Central British Columbia; *Quaternary Research,* Volume 34, pages 208-228.

Clarkson, R. (1991): Placer Gold Recovery Research, Final Summary; report prepared for the Klondike Placer Miners Association, *New Era Engineering Corporation,* Whitehorse, Yukon, 49 pages.

Cobb, E.H. (1973): Placer Deposits of Alaska; *United States Geological Survey,* Bulletin 1374, 213 pages.

Cockfield, W.E. and Walker, J.F. (1933): Geology and Placer Deposits of Quesnel Forks Area, Cariboo District, British Columbia; *Geological Survey of Canada,* Summary Report 1932, Part A 1, pages 76-151.

Day, S.J. and Fletcher, W.K. (1989): Effects of Valley and Local Channel Morphology on the Distribution of Gold in Stream Sediments from Harris Creek, British Columbia, Canada; *Journal of Geochemical Exploration,* Volume 32, pages 1-16.

Day, S.J. and Fletcher, W.K. (1991): Formation of Gold Placers in a Gravel-bed Stream, *Journal of Sedimentary Petrology,* Volume 61, pages 871-883.

Desloges, J.R. and Church, M. (1987): Channel and Floodplain Facies in a Wandering Gravel-bed River; *Society of Economic Paleontologists and Mineralogists,* pages 99-109.

Eyles, N. (1990): Post-depositional Nugget Accretion in Cenozoic Placer Gold Deposits; Cariboo Mining District, British Columbia; *in* Exploration in British Columbia 1989, *B.C. Ministry of Energy, Mines and Petroleum Resources,* pages 147-169.

Eyles, N. and Kocsis, S. P. (1988): Gold Placers in Pleistocene Glacial Deposits; Barkerville, British Columbia; *Canadian Institute of Mining and Metallurgy,* Bulletin, Volume 81, pages 71-79.

Eyles, N. and Kocsis, S.P. (1989a): Sedimentological Controls on Gold Distribution in Pleistocene Placer Deposits of the Cariboo Mining District, British Columbia; *in* Geological Fieldwork 1988, *B.C. Ministry of Energy, Mines and Petroleum Resources,* Paper 1989-1, pages 377-385.

Eyles, N. and Kocsis, S.P. (1989b): Sedimentological Controls on Gold in a Late Pleistocene Glacial Placer Deposits, Cariboo Mining District, British Columbia, Canada; *Sedimentary Geology,* Volume 65, pages 45-68.

Faizullin, R.M. (1969): Lithological-facies Characteristics and the Gold Contents of a Series of Conglomerates of the Kamensk Deposit; *Chemical Abstracts,* Volume 70, page 108202b.

Ferguson, S.A. and Freeman, E.B. (1978): Ontario Occurrences of Float, Placer Gold and Other Heavy Minerals; *Ontario Geological Survey,* Mineral Deposits Circular 17, 214 pages.

Fletcher, W.K. and Wolcott, J. (1991): Transport of Magnetite and Gold in Harris Creek, British Columbia, and Implications for Exploration; *Journal of Geochemical Exploration,* Volume 41, pages 253-274.

Galloway, J.D. (1921): North-eastern District; *B.C. Ministry of Energy, Mines and Petroleum Resources,* 1920 Annual Report, pages 79-105.

Giusti, L. (1986): The Morphology, Mineralogy and Behavior of "Fine-grained" Gold from Placer Deposits of Alberta, Sampling and Implications for Mineral Exploration; *Canadian Journal of Earth Sciences,* Volume 23, pages 1662-1672.

Harvey, A.M. (1984): Debris Flows and Fluvial Deposits in Spanish Quaternary Alluvial Fans: Implications for Fan Morphology; *in* Sedimentology of Gravels and Conglomerates, Koster, E.H. and Steel, R.J., Editors, *Canadian Society of Petroleum Geologists,* Memoir 10, pages 123 -132.

Hein, F.J. (1984): Deep Sea and Fluvial Braided Channel Conglomerates: a Comparison of Two Case Studies; *in* Sedimentology of Gravels and Conglomerates, Koster, E.H. and Steel, R.J., Editors, *Canadian Society of Petroleum Geologists,* Memoir 10, pages 33-49.

Hein, F.J. and Walker, R.G. (1977): Bar Evolution and Development of Stratification in the Gravelly Braided Kicking Horse River, B.C.; *Canadian Journal of Earth Sciences,* Volume 14, pages 562-572.

Herail, G. (Editor) (1991): International Symposium on Alluvial Gold Placers, Abstract Volume; La Paz, Bolivia.

Herail, G., Fornari, M. and Rouhier, M. (1989a): Geomorphological Control of Gold Distribution and Gold Particle Evolution in Glacial and Fluvioglacial Placers of the Ancocala-Ananea Basin, Southeastern Andes of Peru; *Geomorphology,* Volume 2, pages 369-383.

Herail, G., Fornari, M., Viscarra, G., Laubacher, G., Argollo, J. and Miranda, V. (1989b): Geodynamic and Gold Distribution in the Tipuani-Mapiri Basin, Bolivia; *in* International Symposium on Intermontane Basins, Geology and Resources, Chaing Mai, Thailand, pages 342-352.

Herail, G., Fornari, M., Viscarra, G. and Miranda, V. (1990): Morphological and Chemical Evolution of Gold Grains During the Formation of a Polygenic Fluviatile Placer: The Mio-Pleistocene Tipuani Placer Example, Andes, Bolivia; *Chronique de la Récherche Minière,* Volume 500, pages 41-49.

Hirvas, G. (1991): Glacial Transport of Gold in Overburden in Ananea, Peru; *in* International Symposium on Alluvial Gold Placers, Abstracts, Herail, G., Editor, La Paz, Bolivia, page 77.

Hilchey, G.R. (1990): Techniques of Placer Exploration and Mining in Canada; unpublished report, *Energy, Mines and Resources Canada,* 96 pages.

Hilchey, G. R. and Mitchell, M. A. (1986): Report on the Snowshoe Creek Placer and Mineral Properties of Yanks Peak Resources Ltd., Cariboo Mining District, British Columbia; unpublished report prepared for *Yanks Peak Resources Ltd.*, 31 pages.

Holland, S. S. (1948): Report on the Stanley Area, Cariboo Mining Division; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Bulletin 26, 66 pages.

Holland, S. S. (1950): Placer Gold Production of British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Bulletin 28, 89 pages.

Holland, S.S. (1954): Geology of the Yanks Peak - Roundtop Mountain Area, Cariboo District, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 34, 102 pages.

Hughes, R.A. (1989): The Denali Placer Gold Mine; *The Alaska Miner*, Volume 17, Number 10, pages 14-15,19.

Ikona, C.K. and Darney, R.J. (1992): Summary Report on the 1992 Placer Testing Program, Lightning Bench, Hannandor Project; unpublished report, *Gallery Resources Limited*, 21 pages.

Johnston, W.A. and Uglow, W.L. (1926): Placer and Vein Gold Deposits of Barkerville, Cariboo District, British Columbia; *Geological Survey of Canada*, Memoir 149, 246 pages.

Johnston, W.A. and Uglow, W.L. (1933): Placer and Vein Gold Deposits of Barkerville, Cariboo District, British Columbia; *Geological Survey of Canada*, Summary Report 1932, Part A 1, pages 1-75.

Kartashov, I.P. (1971): Geological Features of Alluvial Placers; *Economic Geology*, Volume 66, pages 879 - 885.

Kazakevitch, Y. (1972): Conditions of Formation and Preservation of Composite Buried Gold Placers; *Izd. Nedra Publ. House*, Moscow, 215 pages.

Knight, J. and McTaggart, K. (1986): The Composition of Placer and Lode Gold from the Fraser River Drainage Area, Southwestern British Columbia; *Canadian Institute of Mining and Metallurgy*, Geological Journal, Volume 1, Number 1, pages 21-30.

Knight, J. and McTaggart, K. (1990): Lode and Placer Gold of the Coquihalla and Wells Areas, British Columbia (92H, 93H); *in* Geological Fieldwork 1989, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1990-1, pages 105-118.

Kochel, R.C. and Johnson, R.A. (1984): Geomorphology and Sedimentology of Humid-temperate Alluvial Fans, Central Virginia; *in* Sedimentology of Gravels and Conglomerates, Koster, E.H. and Steel, R.J., Editors, *Canadian Society of Petroleum Geologists*, Memoir 10, pages 109-122.

Krapez, B. (1985): The Ventersdorp Contact Placer: A Gold-Pyrite Placer of Stream and Debris Flow Origins from the Archean Witwatersrand Basin of South Africa; *Sedimentology*, Volume 32, pages 223-224

Larsen, V. and Steel, R.J. (1978): The Sedimentary History of a Debris Flow Dominated Alluvial Fan: A Study of Textural Inversion; *Sedimentology*, Volume 25, pages 37-59.

Lay, D. (1940): Fraser River Tertiary Drainage-history in Relation to Placer -gold Deposits. *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 3, 30 pages.

Lay, D. (1941): Fraser River Tertiary Drainage-history in Relation to Placer - gold Deposits, Part 2; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 11, 75 pages.

Levson, V.M. (1990): Geologic Settings of Buried Placer Gold Deposits in Glaciated Regions of the Canadian Cordillera; *Geological Association of Canada - Mineralogical Association of Canada*, Program with Abstracts, Volume 15, page A-76.

Levson, V.M. (1991a). The Bullion Mine; a Large Buried-valley Gold Placer. *The Cariboo Miner*, Volume 2, Number 5, pages 8-9.

Levson, V.M. (1991b): Geologic Controls on Alluvial Gold Mining in the Cariboo District, British Columbia, Canada; *in* Alluvial Mining, *Elsevier Science Publishers Ltd.* for *Institution of Mining and Metallurgy*, pages 245-267.

Levson, V.M. (1992a). Quaternary Geology of the Atlin Area, (104N/11W, 104N/12E); *in* Geological Fieldwork 1991, Grant, B. and Newell, J.M., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1992-1, pages 375-390.

Levson, V.M. (1992b): The Sedimentology of Pleistocene Deposits Associated with Placer Gold Bearing Gravels in the Livingstone Creek Area, Yukon Territory; *in* Yukon Geology - Volume 3, Bremner, T., Editor, *Yukon Exploration and Geological Services Division*, pages 99-132.

Levson, V.M. and Blyth, H. (1993): Quaternary Paleoplacer Deposits in the Atlin Area; *in* Applied Quaternary Research; *Canadian Quaternary Association*, Program with Abstracts and Field Guide, page A28.

Levson, V.M. and Blyth, H. (in press): Applications of Quaternary Geology to Placer Deposit Investigations in Glaciated Areas; A Case Study, Atlin, British Columbia, *Quaternary International.*

Levson, V.M. and Giles, T.R. (1991): Stratigraphy and Geologic Settings of Gold Placers in the Cariboo Mining District (93A, B, G, H); *in* Geological Fieldwork 1990, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1991-1, pages 331-344.

Levson, V.M. and Kerr, D.K. (1992): Surficial Geology and Placer Gold Settings of the Atlin - Surprise Lake area, NTS 104 N/11, 12; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1992-7, 1:50 000.

Levson, V.M. and Morison, S.R. (1991). Quaternary Gold Placers in the Canadian Cordillera; *International Union for Quaternary Research*, XIII International Congress, Abstracts, page 191.

Levson, V.M. and Rutter, N.W. (1988): A Lithofacies Analysis and Interpretation of Depositional Environments of Montane Glacial Diamictons, Jasper, Alberta, Canada; *in* Genetic Classification of Glacigenic Deposits, Goldthwait, R.P. and Matsch, C.L., Editors, *Balkema*, Rotterdam, pages 117-140.

Levson, V.M. and Morison, S.R. (in press): Geology of Placer Deposits in Glaciated Environments; *in* Glacial Environments - Processes, Sediments and Landforms, Menzies, J., Editor, *Pergamon Press*, Oxford, U.K., 44 pages.

Levson, V.M., Giles, T.R., Bobrowsky, P.T. and Matysek, P.F. (1990): Geology of Placer Deposits in the Cariboo Mining District, British Columbia; Implications for Exploration; *in* Geological Fieldwork 1989, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1990-1, pages 519-530.

Levson, V.M., Clarkson, R. and Douma, M. (1993a): Evaluating Buried Placer Deposits in the Cariboo Region of Central British Columbia (93A, B, G, H); *in* Geological Fieldwork 1992, Grant, B. and Newell, J.M., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1993-1, pages 463-474.

Levson, V.M., Douma, M. and Pilon, J. (1993b): Using Reverse-circulation Drilling, Radar, Seismic and Borehole Logging Tools to Define Buried Placer Deposits; *in* Applied Quaternary Research; *Canadian Quaternary Association*, Program with Abstracts and Field Guide, page A29.

Levson, V.M., Giles, T.R., Morison, S.R. and Blyth, H. (1993c): Paleochannel Placer Deposit Models in the Canadian Cordillera; *Geological Association of Canada - Mineralogical Association of Canada*, Joint Annual Meeting, Program with Abstracts, Volume 18, page A-59.

Lowe, D.R. (1979): Sediment Gravity Flows: Their Classification and Some Problems of Application to Natural Flows and Deposits; *in* Geology of Continental Slopes, Doyle, O.H., and Pilkey, O.H., Editors, *Society of Economic Paleontologists and Mineralogists,* Special Publication 27, pages 75-82.

Lowe, D.R. (1982): Sediment Gravity Flows II - Depositional Models with Special Reference to the Deposits of High Density Turbidity Currents; *Journal of Sedimentary Petrology,* Volume 52, Number 1, pages 279-297.

Mann, A.W. (1984): Mobility of Gold and Silver in Lateritic Weathering Profiles: Some Observations from Western Australia; *Economic Geology,* Volume 70, pages 38-49.

Maurice, Y.T. (1986): Distribution and Origin of Alluvial Gold in Southwest Gaspésie, Quebec; *in* Current Research, Part B, *Geological Survey of Canada,* Paper 86-1B, pages 785-795.

Maurice, Y.T. (1988): Regional Alluvial Heavy Mineral Geochemistry as a Prospecting Method in Glaciated Appalachian Terrain: A Case History from the Southern Quebec Placer-gold Belt; *in* Prospecting in Areas of Glaciated Terrain - 1988, MacDonald, D.R., Editor, *Canadian Institute of Mining and Metallurgy,* pages 185-203.

McKeown, P.R. and McKeown, V. (1989): McKeown Mines Spanish Mountain Project, Report and Prospectus on PML 3135Q, 6483, 6821, 7038, Pl 2706 and 1466, Spanish Mountain, Cariboo Mining Division; unpublished report, *McKeown Mines Ltd.,* 17 pages and appendices.

Miall, A.D. (1977): A Review of the Braided-river Depositional Environment; *Earth Science Reviews,* Volume 13, pages 1-62.

Ministry of Energy, Mines and Petroleum Resources (1992): British Columbia Mineral Statistics, Annual Summary Tables, Historical Mineral Production to 1990; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Mineral Policy Branch, 77 pages.

Minter, W.E.L. (1991): Ancient Placer Gold Deposits; *in* Gold Metallogeny and Exploration, Foster, R.P., Editor, *Blackie,* pages 283-308.

Minter, W.E.L., Feather, C.E. and Glatthaar, C.W. (1988): Sedimentological and Mineralogical Aspects of a Newly Discovered Witwatersrand Deposit that Reflect Proterozoic Weathering, Welkom Goldfield, South Africa; *Economic Geology,* Volume 83, pages 481-491.

Minter, W.E.L., Goedhart, M., Knight, J. and Frimmel H.E. (1993): Morphology of Witwatersrand Gold Grains from the Basal Reef: Evidence for their Detrital Origin; *Economic Geology,* Volume 88, pages 237-248.

Morison, S.R. (1983a): Surficial Geology of Clear Creek Drainage Basin, Yukon Territory (NTS sheets 115 P, 11, 12, 13, 14); *Canada Department of Indian and Northern Affairs, Yukon Exploration and Geological Services Division, Northern Affairs Program,* Open File 1983-2, 1:50 000.

Morison, S.R. (1983b): A Sedimentologic Description of Clear Creek Fluviatile Sediments (115P) Central Yukon: *in* Yukon Exploration and Geology 1982, *Canada Department of Indian and Northern Affairs, Yukon Exploration and Geological Services Division,* pages 50-54.

Morison, S.R. (1985): Placer Deposits of Clear Creek Drainage Basin (115P), Central Yukon; *in* Yukon Exploration and Geology 1983, *Canada Department of Indian and Northern Affairs, Yukon Exploration and Geological Services Division,* pages 88-93.

Morison, S.R. (1989): Placer Deposits in Canada; *in* Quaternary Geology of Canada and Greenland, Fulton, R.J., Editor, *Geological Survey of Canada,* Geology of Canada, Number 1, pages 687-694.

Morison, S.R. and Hein, F.J. (1987): Sedimentology of the White Channel Gravels, Klondike Area, Yukon Territory: Fluvial Deposits of a Confined Valley; *Society of Economic Paleontologists and Mineralogists,* Special Publication 39, pages 205-216.

Mosley, M.P. and Schumm, S.A. (1977): Stream Junctions - a Probable Location for Bedrock Placers; *Economic Geology,* Volume 72, pages 691-694.

Neill, C.R. (1973): Hydraulic and Morphologic Characteristics of Athabasca River near Fort Assiniboine, Alberta; *Alberta Research Council,* Highway and River Engineering Division Report, REH73-7, 23 pages.

Nelson, C.H. and Hopkins, D.M. (1972): Sedimentary Processes and Distribution of Particulate Gold in the North Bering Sea; *United States Geological Survey,* Professional Paper 689, 27 pages.

Nemec, W. and Steel, R.J. (1984): Alluvial and Coastal Conglomerates: Their Significant Features and Some Comments on Gravelly Mass-flow Deposits; *in* Sedimentology of Gravels and Conglomerates, Koster, E.H. and Steel, R.J., Editors, *Canadian Society of Petroleum Geologists,* Memoir 10, pages 1-31.

Panteleyev, A. and Hancock, K. (1989a): Geology of the Beaver Creek and Horsefly Map Areas, NTS 93 A/5, 6; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Open File 1989-14, 1:50 000.

Panteleyev, A. and Hancock, K. (1989b): Quesnel Mineral Belt: Summary of the Geology of the Beaver Creek - Horsefly River Map Area; *in* Geological Fieldwork 1988, *B.C. Ministry of Energy, Mines and Petroleum Resources,* Paper 1989-1, pages 159-165.

Pizey, M.H. (1991): History and Current Practice of Alluvial Gold Mining, New Zealand; *in* Alluvial Mining, *Elsevier Science Publishers Ltd.* for *Institution of Mining and Metallurgy,* pages 422- 442.

Postma, G. (1986): Classification for Sediment Gravity-flow Deposits Based on Flow Conditions During Sedimentation; *Geology,* Volume 14, pages 291-294.

Raicevic, D. and Cabri, L.J. (1976): Mineralogy and Concentration of Au- and Pt-bearing Placers from the Tulameen River Area in British Columbia; *Canadian Institute of Mining and Metallurgy,* Bulletin, Volume 69, pages 111-119.

Read, P.B., Woodsworth, G.J. Greenwood, H.J., Ghent, E.D. and Evenchick, C.A. (1991): Metamorphic Map of the Canadian Cordillera; *Geological Survey of Canada,* Map 1714A, 1:2 000 000.

Reger, R.D. and Bundtzen, T.K. (1990): Multiple Glaciation and Gold-placer Formation, Valdez Creek Valley, Western Clearwater Mountains, Alaska; *Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys,* Professional Report 107, 29 pages.

Reimchen, T. (1990): New Methods Used to Detect a Pre-glacial Buried Channel in the Swift River Area of Central British Columbia; unpublished paper, *Ninth RMS Ross International Placer/Fine Gold Recovery Seminar,* Richmond, British Columbia.

Roed, M.A. (1988): Geological Report on 1988 Work, MC 1 and MC 2 Mineral Claims, Cottonwood Area, Cariboo Mining

Division, NTS 93G 1/E; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 18 328, 54 pages.

Rouse, G.E. and Mathews, W.H. (1979): Tertiary Geology and Palynology of the Quesnel Area, British Columbia; *Canadian Petroleum Geology*, Bulletin, Volume 27, pages 418-445.

Rouse, G.E., Lesack, K.A. and Hughes, B.L. (1990): Palynological Dating of Sediments Associated with Placer Gold Deposits in the Barkerville - Quesnel - Prince George Region, South-central British Columbia; *in* Geological Fieldwork 1989, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1990-1, pages 531-532.

Rust, B.R. and Koster, E.H. (1984): Coarse Alluvial Deposits; *in* Facies Models, Second Edition, Walker, R.G., Editor, *Geological Association of Canada*, Geoscience Canada Reprint Series 1, pages 53-69.

Saarnisto, M., Tamminen, E. and Vaasjoki, M. (1991): Gold in Bedrock and Glacial Deposits in the Ivalojoki Area, Finnish Lapland; *Journal of Geochemical Exploration*, Volume 39, pages 303-322.

Samson, J. (1984): An Overview of Coastal and Marine Gold Placer Occurrences in Nova Scotia and British Columbia; *Energy, Mines and Resources Canada, Ocean Mining Division, Canada Oil and Gas Lands Administration, iInternal publication, 162 pages.*

Scott, K.M., Pringle, P.T. and Vallance J.W. (1992): Sedimentology, Behavior and Hazards of Debris Flows at Mount Ranier, Washington; *United States Geological Survey*, Open-File Report 90-385, 106 pages.

Sharpe, R.F. (1939): The Bullion Hydraulic Mine; *The Miner*, pages 37-40.

Shilts, W.W. and Smith, S.L. (1986): Stratigraphy of Placer Gold Deposits; Overburden Drilling in Chaudière Valley, Quebec; *Geological Survey of Canada*, Paper 86-1A, pages 703-712.

Shilts, W.W. and Smith, S.L. (1988): Glacial Geology and Overburden Drilling in Prospecting for Buried Gold Placer Deposits, Southeastern Quebec; *in* Prospecting in Areas of Glaciated Terrain - 1988, Macdonald, D.R., Editor, *Canadian Institute of Mining and Metallurgy*, pages 141-169.

Shultz, A.W. (1984): Subaerial Debris-flow Deposition in the Upper Paleozoic Cutler Formation, Western Colorado; *Journal of Sedimentary Petrology*, Volume 54, pages 759-772.

Slingerland, R. and Smith, N.D. (1986): Occurrence and Formation of Water-laid Placers; *Annual Reviews, Earth and Planetary Science*, Volume 76, pages 47-56.

Smith, D.G. and Jol, H.M. (1992): Ground-penetrating Radar Investigation of a Lake Bonnevile Delta, Provo Level, Brigham City, Utah; *Geology*, Volume 20, pages 1083-1086.

Smith, G.A. (1986): The Influence of Explosive Volcanism on Fluvial Sedimentation: the Deschutes Formation (Neogene) in Central Oregon; *Journal of Sedimentary Petrology*, Volume 57, pages 613-629.

Smith, G.A. (1987): Coarse-grained Non-marine Volcaniclastic Sediments; Terminology and Depositional Processes; *Geological Society of America, Bulletin*, Volume 97, pages 1-10.

Smith, N.D. and Minter, W.E.L. (1980): Sedimentologic Controls of Gold and Uranium in Two Witwatersrand Paleoplacers; *Economic Geology*, Volume 75, pages 1-14.

Smith, T.E. (1970): Gold Resource Potential of the Denali Bench Gravels; Valdez Creek Mining District, Alaska; *United States Geological Survey*, Professional Paper 700-D, pages 146-152.

Smith, T.E. (1981): Geology of the Clearwater Mountains, South-central Alaska; *Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys*, Geologic Report 60, 72 pages.

Stebbins, S.A. (1987): Cost Estimation Handbook for Small Placer Mines; *United States Department of the Interior, Bureau of Mines*, Information Circular 9170, 94 pages.

Stevens, D. (1983): Bedrock Sources of Placer Gold; in Alaskan Placer Mining, Campbell, B.W., Madonna, J. and Husted, M.S., Editors, *University of Alaska*, Mineral Industry Research Laboratory Report Number 68, pages 46-48.

Struik, L.C. (1982): Bedrock Geology of the Cariboo Lake (93A/14), Spectacle Lake (93H/3), Swift River (93A/13) and Wells (93H/4) Map Areas, Central British Columbia; *Geological Survey of Canada*, Open File 858.

Struik, L.C. (1986): Imbricated Terranes of the Cariboo Gold Belt with Correlations and Implications for Tectonics in Southeastern British Columbia; *Canadian Journal of Earth Sciences*, Volume 23, pages 1047-1061.

Struik, L C. (1988): Structural Geology of the Cariboo Gold Mining District, East-central British Columbia; *Geological Survey of Canada*, Memoir 421, 100 pages and four 1:50 000 maps (1635D: Cariboo Lake (93A/14), 1635A: Spectacle Lake (93H/3), 1635C: Swift River (93A/13); *1635B: Wells (93H/4)).*

Sutherland, D.G. (1985): Geomorphological Controls on the Distribution of Placer Deposits; *Journal of the Geological Society*, Volume 142, pages 727-737.

Sutherland Brown, A. (1957): Geology of the Antler Creek Area, Cariboo District, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 38, 105 pages.

Sutherland Brown, A. (1963): Geology of the Cariboo River Area, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 47, 60 pages.

Teeuw, R.M., Thomas, M.F. and Thorp, M.B. (1991): Geomorphology Applied to Exploration for Tropical Placer Deposits; *in* Alluvial Mining, *Elsevier Science Publishers Ltd.* for *Institution of Mining and Metallurgy*, pages 458-480.

Tipper, H.W. (1959): Geology, Quesnel, Cariboo District, British Columbia; *Geological Survey of Canada*, Map 12-1959, 1: 250 000.

Tipper, H.W. (1961): Geology, Prince George, British Columbia; *Geological Survey of Canada*, Map 49-1960, 1: 250 000.

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

Tipper, H.W., Campbell, R.B., Taylor, G. and Stott, D.F. (1979): Parsnip River, British Columbia; *Geological Survey of Canada*, Map 1424A, 1:1 000 000.

Uglow, W. L. and Johnston, W.A. (1923): Origin of the Placer Gold of the Barkerville Area, Cariboo District, British Columbia, Canada; *Economic Geology*, Volume 18, pages 541-561.

Vasconcelos, P. and Kyle, R.J. (1989): Supergene Geochemistry and Crystal Morphology of Gold in a Semi-arid Weathering Environment, Application to Gold Prospecting; *in* 13th International Geochemical Exploration Symposium, Rio de Janeiro 1989, *Association of Exploration Geochemists*, pages 22-24.

Walton, A.W. and Palmer B.A. (1988): Lahar Facies of the Mount Dutton Formation (Oligocene-Miocene) in the Marysvale

Volcanic Field, Southwestern Utah; *Geological Society of America,* Bulletin, Volume 100, pages 1078-1091.

Wells, N.A. (1984): Sheet Debris Flow and Sheet Flood Conglomerates in Cretaceous Cool-maritme Alluvial Fans, South Orkney Islands, Antarctica; *in* Sedimentology of Gravels and Conglomerates, Koster, E. H. and Steel, R.J., Editors, *Canadian Society of Petroleum Geologists,* Memoir 10, pages 133-145.

Williams, G.J., (1974): Economic Geology of New Zealand; *The Australasian Institute of Mining and Metallurgy,* 490 pages.

Wilson, M.V.H. (1977): Paleoecology of Eocene Lacustrine Varves at Horsefly, British Columbia; *Canadian Journal of Earth Sciences,* Volume 14, pages 953-962.

Yeend, W. (1991): Experimental Abrasion of Detrital Gold in a Tumbler; *in* Geological Studies in Alaska, Bradley , D.W. and Dusel-Bacon, C., Editors, *United States Geological Survey,* Bulletin 2041, pages 86-92.

Yeend, W. and Shawe, D.R. (1989): Gold in Placer Deposits; *United States Geological Survey,* Bulletin *1857(G), pages 1-13.*

APPENDICES

APPENDIX A
INDEX OF PROPERTIES, OWNERS AND OPERATORS

PROPERTY LOCATION IN TEXT:

APPENDIX B
MEASURED SECTIONS

ORGANIZATION

Measured sections are organized by the geologic settings described in Chapters 3 and 4 and they are presented in the same order as in Chapter 5. Measured sections are listed numerically by the last two digits of the year they were described, followed by the location number and by an alphabetic designation for sites where more than one section was measured. Thus Section 8901F was measured in 1989 at Site 1, location F.

- The section descriptions for each site are preceded by data identifying:
- name of stream, area or mine site;
- owner(s)/operator(s) at the time of the property visit;
- National Topographic Series (NTS) map designation (1:50 000);
- Latitude and longitude;
- Universal Transverse Mercator (UTM) grid designation (to the nearest 100 metres);
- year of property visit.

DATA PRESENTATION:

Each measured section is preceded by a brief site description including data such as the location on the property, access, geomorphic setting and mining activity. Stratigraphic units are numbered from oldest to youngest in all cases. Depth below the surface or, height above the section base (Height above base) are given in metres for each unit. Unit descriptions begin with lithology (sediment type) and are followed by data, where applicable, on:

- sedimentary structures (types of stratification or cross-stratification, grading, bed thickness, imbrication, strata dip and dip direction, nature of interbeds and lenses etc.)
- framework (clast supported, matrix supported, openwork)
- fabric (in gravel: unorganized; a-axis transverse, b-axis imbricate [at-bi]; or a-axis parallel, a-axis imbricate [ap-ai]; in diamictons: a-axis orientation data [trend and plunge] and fabric strength [eigenvalue])
- paleoflow directions
- grain-size distribution and sorting
- clast lithology (lithologies of all analyzed samples are listed in Appendix C by section and unit number)
- clast size (average and range), and roundness
- matrix texture, colour and mineralogy
- soft-sediment (syndepositional) deformation structures (fluid escape and dish structures, sand pillows etc.)
- structural (post-depositional) deformation features (type and abundance of faulting, folding, slickensides, shear planes, etc.)
- lateral and vertical variations in lithofacies, structure and secondary characteristics
- cementation
- oxidation or staining
- compaction
- organic content
- jointing
- sample number and type
- lower contact geometry and distinctness (sharp, clear or gradational) and evidence for unconformity (*e.g.*, scour structures, crosscut bedding etc.).

TERTIARY PLACERS (LOCATIONS 1 to 4)

SITE 1 - QUESNEL RIVER - BIG CANYON AREA

Owner/operator: Lee Frank and Debbie Corless / Farrow Mineral Development Corp.
NTS: 93G/1 Cottonwood; 93B/16 Quesnel River
Latitude & Longitude: 53°00'N, 122°23'W
UTM: 5872000 m N, 542300 m E
Year of property visit: 1989

Site Description:

This site is located on a series of terraces along the Quesnel River near Big Canyon, about 3 kilometres east of Quesnel. In 1989, there was a large exploration project (Farrow Resources) on a high terrace and a small active mine (Corless mine) on a low terrace, both on the south side of the river (*see* also Site 48). The location of measured sections in the area are shown on Figure 15 and a schematic cross-section is given in Figure 16.

Section 8901A/B

Location: Cut-bank exposure at the downstream end of Big Canyon on the south side of Quesnel River (Figure 15).

Unit	Height above base (m)	Description:
11	7.8 - 9.0	Large-pebble gravel: crude horizontal bedding; imbricated (paleoflow towards 060°); clasts up to small-cobble size; poorly sorted; 20% fine to coarse sand matrix; weakly cemented and oxidized; lower contact gradational.
10	7.6 - 7.8	Small to medium-pebble gravel: horizontal to low-angle planar crossbedding (dips 06° toward 205°); some finely crystalline yellow precipitate (possibly sulphurous); moderately sorted; openwork at base, coarse sandy matrix in upper part; lower contact clear and horizontal.
9	7.5 - 7.6	Coarse sand: horizontally laminated; well sorted; sands angular with ~50% quartz and 50% dark minerals); some granules; weakly cemented; contains wood and plant fragments (Sample 8936); lower contact clear and horizontal (conformable).
8	7.0 - 7.5	Pebble to cobble gravel: imbricated (westerly paleoflow) poorly sorted; ~20% cobbles, 50% pebbles and 30% medium sand to granules; clasts subangular to well rounded; cemented; some coarse-grained igneous clasts; unit thickens laterally to about 3 metres; lower contact erosional.
7	6.0 - 7.0	Pebble to cobble gravel: poorly to moderately sorted; ~20-25% cobbles, 50% pebbles and 25-30% fine sand to granules; clasts subrounded to well rounded; semi-prominent; lower contact gradational.
6	4.6 - 6.0	Large-pebble gravel: horizontal bedding; moderately to well sorted; ~5% cobbles; 5-10% sand matrix; semi-prominent; lower contact gradational.
5	4.2 - 4.6	Large-pebble gravel: low-angle, large-scale trough crossbedding; dip and dip direction as in Unit 3; well sorted; 5% sand matrix; clasts dominantly equants (spherical) with few blade or disc-shaped clasts; semi-recessive; lower contact gradational.
4	3.3 - 4.2	Coarse pebble-cobble gravel: horizontal to low-angle trough crossbedding; dip and dip direction as in Unit 3; 10% sandy matrix; ~20-25% cobbles and 75% pebbles; well imbricated (E to NE paleoflow); poorly to moderately sorted; rounded to well-rounded clasts; semi-prominent; unit thickens to the northeast to 2.2 metres lower contact erosional and crosscuts beds in Units 2 and 3.
3	2.6 - 3.3	Pebble to cobble gravel: low-angle (04°), large-scale (beds laterally traceable for >30 metres) trough crossbedding; some normal grading with large pebble-cobble gravel fining upward to small to medium gravel; poorly sorted; ~15% matrix; weak imbrication; ~15% cobbles; semi-recessive; lower contact gradational.
2	1.2 - 2.6	Medium to large-pebble gravel: clast supported; low-angle trough crossbedding; beds dip toward the northwest (330°); dip increases to ~7° in more northerly exposures; moderately to well sorted;10-15% matrix; few cobbles (5%); less strongly cemented and stained; pebble fabric 890111 taken at 2.5 metres, well imbricated [paleoflow to the NE (060° to 090°)], clasts rounded to well rounded; semi-prominent; lower contact dips 05° to the northeast (030°) and is gradational.
1	0 - 1.2	Medium to large-pebble gravel: crude horizontal bedding; some cobbles; few granules and small pebbles; poorly to moderately sorted; ~30% fine to medium sand matrix; strongly cemented with iron and manganese; stained purple; cementation and staining strongest at the base; clasts rounded to well rounded; mainly quartzite, chert and fine-grained volcanics; volcanics commonly strongly weathered; unit is resistant and forms a prominent ridge; lower contact sharp and erosional.
	Bedrock:	1) Intermediate to mafic, fine to medium-grained intrusive: dark green to black colour; hornblende crystals occur in a matrix of medium-grained calcium plagioclase and fine-grained green pyroxene and olivine crystals; interpreted as dioritic to gabbroic dike (hypabyssal).

2) Medium-grained granodioritic intrusion: forms a unit 5-7 metres wide and strikes north; locally is porphyritic with 50% euhedral plagioclase crystals up to 2 centimetres long, 5% subhedral quartz crystals up to 0.5 centimetre long, 5% dark minerals less than 2 millimetres long with poor cleavage (possibly pyroxenes), and about 40% light grey microcrystalline groundmass; unit has a sharp contact with adjacent volcanic rocks, and three joint sets.

3) Fine-grained intermediate to mafic (andesitic to basaltic) extrusive: some siliceous content evidenced by high resistance to weathering and conchoidal fracturing; well-developed jointing pattern; vertical joints most prominent; other joint sets may reflect metamorphosed crude bedding or possible flow structures; locally epidotized; strongly fractured; slickensided shear zones dipping steeply to the north; alteration along shear zones to epidote and sericite; interpreted as andesitic to basaltic layered/pillowed(?) flows with low-grade metamorphism and siliceous hydrothermal alteration; upper surface of the bedrock is smoothed, channelled, and has small potholes, scour marks and flutes (P-forms) trending east (90°-115°).

Section 8901C/D

Location: Exposure on the lower part of the slope between a high and low terrace on the south side of Quesnel River approximately 100 metres southeast of Section 8901A/B (Figure 15).

Unit	Height above base (m)	Description:
5	6.0 - 7.0	Sandy pebble gravel and gravelly diamicton: massive; poorly sorted with a fine to medium sand matrix and few cobbles; unit contains fewer blade and disc-shaped clasts and more equant-shaped clasts than underlying units; lower contact gradational.
4	3.0 - 6.0	Sandy pebble to cobble gravel and fine to medium sand: crude horizontal bedding; some trough-shaped beds; beds 5-50 centimetres thick and laterally discontinuous (1-2 metres); sandy beds are poorly sorted pebble sands, massive to crudely laminated and ungraded; gravel beds have ~40% cobbles, 30% large pebbles and 30% fine sand to medium pebbles; locally openwork; clasts mainly quartzite, chert, intrusives, limestone and conglomerate; clasts dip westward (downslope) suggesting colluviation; uncemented; lower contact gradational.
3	1.6 - 3.0	Large-pebble to cobble gravel: crude horizontal stratification to massive at the top; openwork in places; moderately sorted; moderately cemented; 5-10% fine to coarse sand matrix; well imbricated (paleoflow to the NE to E); lower contact horizontal and clear (conformable).
2	1.1 - 1.6	Pebble to cobble gravel: crude horizontal stratification marked by cobble-rich beds; imbricated (paleoflow 040°-060°) poorly sorted; moderately to strongly cemented; mostly small to medium pebbles, few (~5%) large pebbles; fine to coarse sand matrix; basal part of the unit contains greater than 5% angular clasts of local lithology; lower contact horizontal and clear (conformable).
1	0 - 1.1	Large-pebble gravel: horizontal bedding; beds 10-20 centimetres thick; large pebbles (40%) with cobble layers (<5%); moderately sorted; moderately to strongly cemented; clasts are rounded to well rounded; abundant chert and quartzite; some strongly weathered volcanics and rare intrusives; 15-20% fine sand to coarse sand matrix; lower contact covered.

Section 8901E

Location: Exposure near the centre of a low terrace on the south side of Quesnel River approximately 100 metres southwest of Section 8901A/B (Figure 15).
See Site 48 for section description.

Section 8901F (Hess Site)

Location: Natural slope exposure a few hundred metres upstream from Section 8901H on the south side of Quesnel River (Figure 15).

Unit	Height above base (m)	Description:
8	5.7 - 6.7	Small to large-cobble gravel: disorganized; some boulders up to 0.5 metre diameter; poorly sorted; some angular siltstones; ~50% cobbles and boulders, 35% pebbles and 15% fine to coarse sand matrix; oxidized and moderately well cemented; lower contact erosional.
7	4.7 - 5.7	Small to large-pebble gravel: no cobbles; crude horizontal stratification; subangular to well-rounded clasts; fine to coarse sand matrix; poorly exposed; lower contact sharp.
6	3.7 - 4.7	Medium to large-pebble gravel with interbedded sand lenses: horizontal bedding; pebble beds poorly sorted with a coarse sand matrix; numerous lenses of well-sorted medium sands and granular to small pebbly sands; sand lenses 10-40 centimetres thick and 0.5-3.0 metres wide; sands trough crosslaminated (channel-fill bedding) or horizontally laminated; lower contact gradational.
5	3.1 - 3.7	Large-pebble gravel: massive; silt to coarse sand matrix; unit fines upward to a medium to large-pebble gravel; poorly sorted; lower contact gradational.

4	2.6 - 3.1	Medium to large-pebble gravel: horizontally stratified; minor cobble-clast clusters at the base; unit grades up from large to medium pebbles; coarse sand matrix at base to openwork at the top; oxidized; lower contact gradational.
3	2.1 - 2.6	Medium-pebble gravel: crude horizontal stratification; medium to coarse sand matrix; strongly cemented with carbonate; clasts subrounded to well rounded; mainly equidimensional clasts; moderately well sorted; unit is lens shaped; lower contact erosional.
2	2.0 - 2.1	Medium sand: horizontally laminated; well sorted; pebble lithology (sample 8916): 28% quartzite, 12% limestone, 12% vein quartz, 10% chert, 8% shale, 8% siltstone, 10% mafic extrusives (4% amygdaloidal basalt and 6% green intrusives), 10% intrusives (including 2% diorite), and 2% porphyritic andesite; lower contact conformable.
1	0 - 2.0	Large-pebble to cobble gravel: poorly exposed; unit fines upwards; pebble-sized clasts mainly quartzite, sandstone, pebble conglomerate, chert and vein quartz; cobble clasts are mainly fine-grained volcanics, basalts, granite and diorite; lower contact poorly exposed.
	Bedrock:	Calcareous sandstone, quartzitic sandstone; fractured; numerous quartz veins; ~10-12 metres exposed from river level to the section base.

Section 8901G (Hess Site)

Location: A trench 5-7 metres deep a few hundred metres upstream from Section 8901H on the south side of Quesnel River (Figure 15).

Unit	Height above base (m)	Description:
4	6.0 - 6.5	Coarse sands: some sandy granule and small-pebble beds; well-developed planar crossbedding dipping ~5° to the south; a lag pebble concentration occurs at the base; above the lag gravel the unit coarsens upward from mainly sands to granule gravel; unit is trough shaped and thickens to more than 2 metres at the expense of underlying units; lower contact erosional (cuts bedding in Units 2 and 3) and dips 15°-20° to the north.
3	5.5 - 6.0	Large-pebble to cobble gravel: crude planar crossbedding dipping ~5° to the south; poorly sorted; Units 2 and 3 thin laterally to less than 2.5 metres due to erosion by the overlying unit; lower contact erosional.
2	2.0 - 5.5	Sandy pebble gravel: crude planar crossbedding dipping ~5° to the south; bedding is marked by cobble concentrations occurring at 2.0, 3.2, 4.5 and 5.3 metres; lower contact horizontal and conformable.
1	0 - 2.0	Pebbly fine to medium sands: planar crossbedding; less than 5% clasts; lower contact covered.

Section 8901H

Location: Cut-bank exposure on a high terrace on the upstream end of Big Canyon on the south side of Quesnel River (Figure 15).

Unit	Height above base (m)	Description:
10	14.2 - 15.7	Fine sands: horizontally laminated in lower half and massive in upper half; soil horizon development in upper metre; lower contact conformable. Numerous large boulders of various lithologies (granite, diorite, quartzite, calcareous siltstone, rhyolite, porphyritic basalt, gneiss, greenstone) occur on the upper surface of this site.
9	13.5 - 14.2	Small to large-cobble gravel: ~50% cobbles and 50% coarse sand and pebbles; unoxidized, grey colour; moderately cemented; clasts subrounded to well rounded; pebble lithology (sample 8945) 64% quartzite, 12% fine-grained volcanics, 8% vein quartz, 4% granitic, 4% chert, 4% diorite, 4% porphyritic basalt; lower contact gradational.
8	12.5 - 13.5	Medium-pebble gravel: large pebbles and cobbles comprise 10-20% of the unit and are supported by the pebble framework ("matrix supported"); crude horizontal bedding; coarse sand matrix; poorly sorted; oxidized and moderately well cemented; lower contact sharp and horizontal. Pebble fabric 890112.
7	10.7 - 12.5	Medium-pebble to small-cobble gravel: horizontally bedded; beds 0.5-1 metre thick; minor trough-shaped, planar crosslaminated fine sand lenses about 1 metre wide and 10 centimetres thick; upper 20 centimetres of unit is a openwork medium to large-pebble bed with abundant equant clasts and few (~10%) discs and blades; lower contact gradational.
6	9.7 - 10.7	Large-pebble to large-cobble gravel: 10-20% sand matrix; oxidized; dark red colour; lower contact gradational.
5	8.2 - 9.7	Large-pebble to cobble gravel: well imbricated; unit fines upward to a medium to large-pebble gravel; lower contact gradational.
4	6.0 - 8.2	Medium-pebble to small-cobble gravel: well imbricated; ungraded except for a cobble concentration at base; top of bed is marked by an almost openwork large-pebble lens with numerous (up to 20%) volcanic clasts overlain by a bed of openwork, oxidized, small to medium-pebble gravel 20 centimetres thick; lower contact gradational.

3	4.5 - 6.0	Small to large-pebble gravel: minor cobbles; similar to Unit 1; unit fines upward; lower contact gradational.
2	3.7 - 4.5	Cobble gravel: weakly imbricated; medium to coarse sand matrix; unit grades laterally into a more poorly sorted pebble-cobble gravel; lower contact sharp and scoured; scours ~1 metre deep and 8 metres wide.
1	1.0 - 3.7	Large-pebble to cobble gravel: horizontally bedded; some normal grading; moderately well imbricated; matrix filled (10-20% sand matrix); minor oxidized openwork beds; bed contacts mainly gradational; mostly well-rounded quartzite clasts; clasts mainly (~70%) blades and discs; weakly cemented; rare, large, locally derived, angular boulders; beds 1-1.5 metres thick and laterally traceable for more than 10 metres; minor medium-pebble bed at 1.5-1.7 metres; oxidized except for the lower 10-20 centimetres; lower contact unconformable on bedrock. Pebble lithology (sample 8944) taken at 25-30 centimetres depth.
	0 - 1.0	Bedrock: quartzite to quartzose granular sandstone; 7-10 metres exposed; intensely fractured and in the upper 25-50 centimetres is strongly weathered to a disaggregated silty sand; sample 8943; lower contact covered.

Section 8901I

Location: Cut-bank exposure in a low terrace a few hundred metres downstream from Big Canyon on the south side of Quesnel River about 100 metres downstream from Section A/B (Figure 15).

Unit	Height above base (m)	Description:
12	9.0 - 11.0	Small to medium-pebble gravel: planar crossbedding dipping 5-20° to the north (355°); beds 5-20 centimetres thick; some openwork pebble beds; large-pebble and cobble beds rare except for a massive large-pebble to cobble gravel bed in the lower 25-50 centimetres of the unit; moderately sorted; some horizontally laminated, well-sorted, sand lenses, 10-40 centimetres thick; moderately sorted; pebble lithology ~50% quartzite, 30% chert, and 20% coarse-grained igneous; most large clasts are plutonics; lower contact erosional and locally cuts into Units 11 to 5; the contact dips ~15° to the south (190°) and occurs as a series of scours that are ~10-20 metres wide and a few to several metres deep.
11	8.0 - 9.0	Medium to large-pebble gravel: crude horizontal stratification; nearly openwork; moderately to well sorted; unit coarsens upward to a cobble gravel with interbedded small to medium-pebble gravel lenses similar to Unit 10; lower contact conformable.
10	6.0 - 8.0	Cobble gravel: interbedded small to medium-pebble gravel lenses (25 centimetres thick and up to 5 metres wide); few pebbles or boulders in cobble beds; sandy matrix; lower contact erosional.
9	5.5 - 6.0	Small to medium-pebble gravel: similar to Unit 7 except some openwork beds; lower contact conformable.
8	5.0 - 5.5	Medium-pebble to small-cobble gravel: similar to Unit 6 except chaotic to weakly imbricated fabric; unit is a trough-shaped lens ~1 metre thick and 5 metres wide; lower contact erosional.
7	4.5 - 5.0	Small to medium-pebble gravel: ~10% large pebbles; minor small cobbles of angular bedrock; beds in Units 6 and 7 locally dip up to 4° to the south (200°) and contain organics (mainly wood fragments) lower contact trough shaped. Units 7 - 11 are exposed on an inaccessible face and were described from below.
6	3.2 - 4.5	Medium-pebble to small-cobble gravel: massive; moderately imbricated indicating paleoflow to the south; ~35% large pebbles and 10% cobbles; some cobble-clast clusters; lower contact conformable.
5	2.4 - 3.2	Large-pebble gravel: interbeds of small to medium-pebble openwork gravel; crude horizontal bedding; moderately imbricated indicating paleoflow to the south; clasts mainly quartzites, some strongly weathered volcanics (~10%), diorites (~5%) and cherts (~5%); ~20% silt to coarse sand matrix; oxidized with some manganese-stained beds; moderately sorted; Units 1 to 5 locally dip up to about 4° to the south; imbrication in exposures farther north indicates a more easterly paleoflow (050° to 070°); lower contact conformable.
4	2.25 - 2.4	Granular (~85%) to small pebbly (~15%) sand: unit is a thin (commonly only 3-5 centimetres) trough-shaped lens laterally traceable for less than 1 metre; moderately well sorted; abundant organics including wood fragments; lower contact conformable.
3	1.25 - 2.25	Pebble to cobble gravel: unit fines upward from large-pebble and cobble gravel at the base to a medium-pebble gravel; crude horizontal bedding; some openwork, small to medium-pebble beds 5-10 centimetres thick; weakly imbricated suggesting paleoflow to the southeast (140° to 150°); moderately cemented; deeply oxidized in places; beds have sulphurous and manganese deposits (samples 8947A and B); lower contact erosional (clear and planar).
2	1.0 - 1.25	Medium to coarse sand: crude horizontal bedding; moderately well sorted; unit is trough shaped and ~0.25 metre thick and 5 metres wide; oxidized; lower contact conformable.
1	0 - 1.0	Small-cobble gravel: weakly imbricated to disorganized fabric; ~50% granule to medium pebbles, 20% cobbles, 20% large pebbles and 10% sand; clasts well rounded to rounded; ~70% quartzite, 10% weathered siltstone, 10% angular, local bedrock, some soft, green, fine-grained volcanics; medium to coarse sand matrix; poorly sorted; moderately cemented; lower contact unconformable. Bedrock:

Basalt; silicified; dark green colour; irregular joints with oxidized faces; upper 50 centimetres is strongly oxidized, fractured and weathered to a soft, yellow, granular silt.

Section 8901J (Conglomerate Section)

Location: Small cut-bank exposure on the north side of Quesnel River at Big Canyon (Figure 15).

Unit	Height above base (m)	Description:
2	0.6 - 4.0	Small-pebble to large-cobble gravel: clast supported; matrix filled; 70% clasts, 20-30% sandy matrix; well imbricated with paleoflow to the east (85° - 120°); crude horizontal bedding; alternating poorly sorted pebble to cobble-gravel beds (40-60 centimetres thick) and less resistant, moderately sorted (<20% matrix) pebble-gravel beds (30-50 centimetres thick); clasts mainly well rounded, some subrounded; well cemented; pebble lithology (sample 8928) 54% quartzite (44% white, 6% green-grey, 4% pink), 26% vesicular and amygdaloidal, green volcanics, 6% fine-grained crystalline extrusive; 6% chert; 4% diorite; 4% vein quartz; gravel infills bedrock depressions; lower contact undulatory and sharp. Pebble fabric 890109 at 1.6 metres and 890110 at 2.6 metres.
1	0 - 0.6	Bedrock: mafic extrusive and intermediate intrusive volcanics (andesitic/dioritic); hornblende crystals occur in a groundmass of medium-grained calcium plagioclase and fine-grained green pyroxene and amphibole crystals; minor quartz; quartz veins with disseminated pyrite are exposed along a chip-sample trench; locally epidotized; some siliceous content evidenced by high resistance to weathering and conchoidal fracturing; well-developed jointing pattern; vertical joints most prominent; other joint sets may reflect metamorphosed crude bedding or possible flow structures; mafic extrusives interpreted as andesitic to basaltic, layered/pillowed(?) flows with low-grade metamorphism and siliceous hydrothermal alteration; medium-grained, hornblende-plagioclase intrusive interpreted as dioritic to gabbroic hypabyssal rocks.

Section 8901K (Rapids Section)

Location: Cut-bank exposure on the north side of the Quesnel River road about 200 metres downstream from Section 8901J (Figure 15).

Unit	Height above base (m)	Description:
5	4.5 - 8.0	Diamicton: matrix supported; massive in lower 1-2 metres, crude stratification in upper 1-2 metres due to variations in clast, matrix and organic content; some gravel, silt and sand lenses (1-3 metres wide, 10-25 centimetres thick) in upper 1-2 metres; matrix silty sand; 20-30% clasts, mainly small to medium pebbles with rare large pebbles or cobbles; clasts subrounded to well rounded; intraclasts of laminated silt and clay, up to 10 centimetres diameter, common in the lower 60-80 centimetres; mud intraclasts generally rounded but some are subrounded to subangular; wood fragments up to 20 centimetres in diameter also common in the lower 60-80 centimetres; lower contact undulatory (grooves ~10-20 centimetres wide, trending parallel to the slope) and sharp.
4	4.2 - 4.5	Silt and sand: crude horizontal stratification; some sand beds are moderately stratified; sand mainly fine with some medium sand interbeds; unit coarsens up with the lower 15-30 centimetres silty and the upper 5-20 centimetres sandy; wood fragments common in silty beds and rare in sand; silt is locally oxidized (red in colour); lower contact gradational and undulatory.
3	4.0 - 4.2	Cobble gravel: unit coarsens upward from a pebble gravel to a cobble gravel with some boulders; in places the unit consists only of a cobble-boulder lag (one clast thick); blade and disc-shaped clasts are flat lying; unoxidized, grey colour; lower contact subhorizontal and erosional (crosscuts underlying strata).
2	0.5 - 4.0	Medium to very large pebble gravel: few cobbles; clast supported; matrix filled with granular sands; weakly imbricated; crude large-scale trough crossbedding indicating channellized flow to the east and east-southeast; crossbeds are exposed over a distance of 5-8 metres; at least two crossbed sets occur at separate locations 25-30 metres apart with a vertical spacing of 2-3 metres; clasts mainly well rounded (>70%), some subrounded; gravel is well oxidized (iron); strongly to weakly cemented; lower contact undulatory and sharp.
1	0 - 0.5	Bedrock: mafic fine-grained intrusive (basaltic) with granodiorite dike; dark green colour; small hornblende crystals with some calcium plagioclase, pyroxene and olivine crystals visible; jointed; minor quartz; granodioritic dike strikes north, has large potassium feldspar phenocrysts (~40%), a groundmass of fine-grained hornblende, quartz and feldspar, is up to 7 metres wide, has a sharp contact with adjacent volcanic rocks, and three joint sets; upper surface of the bedrock is smoothed, channellized, and has small potholes, scour marks and flutes (P-forms) trending east (90° - 115°).

Section 8901L (Road Section)

Location: Road-cut on the north side of the Quesnel River about 200 metres west of Section 8901J (Figures 15 and 35).

Unit	Height above base (m)	Description:
8	14.0 - 17.0	Silt and clay: horizontally laminated; a thin diamicton interbed occurs at 14.05-14.25 metres and has a silty mud matrix with up to ~20% pebbles and granules; the diamicton thickens to the northeast and has an erosional lower contact; silt and clay is indurated; lower contact gradational.
7	12.0 - 14.0	Small to medium-pebble gravel: unit fines upward into dominantly sandy beds; large-scale trough crossbedding; alternating beds of matrix-filled and openwork gravel; unit fines upward with dominantly sand and sandy granule to pebble beds in the upper half; total clast content more than 70%; well sorted; clasts subrounded to well rounded; gravel similar to Unit 5; unoxidized (grey in colour); lower contact erosional.
6	11.5 - 12.0	Silt, clay and very fine sand: thin horizontal laminae; indurated; clasts rare; unit is lens shaped and thins to the west; lower contact sharp and horizontal.
5	9.0 - 11.5	Small to medium-pebble gravel: large-scale trough crossbedding (channel-fill bedding) infills a broad trough more than 30 metres wide; a coarse cobble and boulder concentration occurs at the base of the unit; trough-shaped scour-fill structures common (10-20 centimetres thick, up to 2 metres wide); scour-fills fine upward from pebbles through granules to medium to coarse sands; beds 3-7 centimetres thick, well sorted; matrix filled with medium sands; minor openwork beds; total clast content greater than 70%; unit thickens laterally to 4 metres; clasts subrounded to well rounded; pebble lithology (sample 8931) 32% quartzite (24% white, 6% brown, 2% red), 18% intrusives (8% coarse-grained diorite, 10% granitic), 28% volcanics [12% basaltic (4% amygdaloidal), 10% intermediate (2% porphyritic dacite), 6% porphyritic rhyolite], 8% greenstone, 10% vein quartz, 4% limestone, 4% oxidized siltstone, 2% chert; gravel unoxidized (grey in colour); lower contact erosional and dips 1-2° to the west.
4	7.0 - 9.0	Large-pebble to small-cobble gravel: clasts range from small pebbles to cobbles with rare boulders; crude, discontinuous stratification; unit coarsens upward; some openwork small to medium-pebble gravel beds; other beds matrix filled with up to 35% sand; large diamicton intraclasts 1 metre thick and 1-3 metres wide (diamicton contains ~60% clasts, mostly pebbles, and a sand-silt matrix; pebble lithology of diamicton clasts, sample 8932); minor cobble-sized clay intraclasts; clasts mostly subrounded but vary from subangular to well rounded; gravel is well oxidized (iron), particularly in openwork beds, but diamicton intraclasts are unoxidized; lower contact erosional (crosscuts underlying unit) and undulatory.
3	5.5 - 7.0	Large-pebble gravel: clasts range from small pebbles to cobbles; clast supported; sandy matrix; ~60% clasts; mainly massive with a disorganized fabric; some crude horizontal and trough crossbedding filling broad, shallow channel-forms; some imbrication in stratified beds indicating paleoflow to the northeast; gravel is well oxidized (iron), especially at the base of unit; pebble lithology (sample 8930) 54% quartzite (38% white, 14% brown, 2% red), 14% chert,10% intrusives (4% coarse-grained diorite, 6% granite), 8% fine sandstone, 6% vein quartz, 6% volcanics (2% basalt, 4% intermediate), 2% limestone; lower contact erosional, dips 5° or more to northeast with undulations less than 1 metre deep and 5-10 metres wide.
2	4.5 - 5.5	Cobble to boulder gravel: clast supported; crude horizontal stratification; unit occurs as trough-shaped lens (1 metre thick and 3 metres wide); matrix sandy; 70% clasts; clasts well rounded to subrounded, mainly quartzite and igneous rocks, largest clasts commonly igneous; lower contact erosional.
1	0 - 4.5	Pebble gravel: mainly large-pebble beds with some small to medium-pebble beds; well stratified and imbricated; clast supported; matrix filled with medium coarse sand; horizontal and low-angle planar crossbedding (beds dip 1°-2° toward the northeast - 060°); imbrication indicates paleoflow to the east - 080° (range in paleoflow directions is from 020°-130°); clasts mainly (70-80%) subrounded to well rounded; clasts are strongly weathered and some, particularly volcanics, are totally decomposed (even quartzites are pitted); pebble lithology sample 8929; lower contact covered.

Section 8901M (River Section)

Location: Cut-bank exposure along the north side of the Quesnel River 300 metres downstream from Section 8901J (Figure 15).

Unit	Height above base (m)	Description
9	20.0 - 26.0	Fine sand, silt and clay: horizontally stratified; graded bedding common; silt and clay laminae less than 5 millimetres to 1 centimetre thick; sand beds up to 3 centimetres thick; unit fines upward.
8	19.1 - 20.0	Pebble gravel: horizontal bedding; poorly sorted; lower contact erosional.
7	18.7 - 19.1	Silt and clay: thin horizontal laminae; unit fines upward from thickly laminated clay at the base to thinly laminated silt at the top; lower contact gradational.

6	18.0 - 18.7	Medium to coarse sand: unit coarsens upward to fine sands; large-scale trough crossbedding (channel-fill bedding); lenses (channels) 20 metres or more wide; some pebble beds at the base of the lenses; lower contact clear and subhorizontal.
5	8.5 - 18.0	Small to large-pebble gravel: cobble beds rare; horizontal bedding and trough crossbedding; fining-upward scour-fill sequences common; sand lenses less than 20 centimetres thick and up to 5 metres wide common; lower contact erosional (scoured).
4	7.0 - 8.5	Medium to coarse sand: horizontally laminated; some trough crossbedding; pebble gravel lenses common; some scour-fill structures with pebble lags fining upward into sands; lower contact gradational.
3	3.0 - 7.0	Small to large-pebble gravel: small cobbles rare; planar crossbedding, trough crossbedding and horizontal bedding; alternating beds of openwork small to medium-pebble gravel and matrix-filled gravel; some thin sand lenses; lower contact erosional.
2	1.5 - 3.0	Sandy pebble gravel and sand: trough cross-stratified; well-sorted, medium to coarse sands; unit fines upward; lower contact gradational.
1	0.0 - 1.5	Small to large-pebble gravel: clast supported; horizontal bedding and trough crossbedding; matrix-filled gravel beds have a well-sorted, fine to coarse sand (infiltration) matrix; mainly horizontally bedded, medium to large-pebble beds in the lower half and trough crossbedded small to medium gravel in the upper half; some manganese-stained openwork beds in the lower 2 metres; total clasts ~70%; pebble lithology 40% fine-grained mafic volcanics, 20% quartzites, 10% limestone, 10% chert; 10% intrusive igneous; 10% shale and ironstone; clasts subrounded to well rounded; paleoflow to the northeast; lower contact covered (about 6 metres to river level).

SITE 2 - FRASER RIVER

Allstar mine
NTS: 93G/2 Cottonwood Canyon
Latitude & Longitude: 53°08'N, 122°40'W
UTM: 5886800 m N, 522000 m E
Year of property visit: 1990

Site Description:

This site is located along the Fraser River about 18 kilometres northwest of Quesnel. At least two underground operations have mined the Tertiary gravel in this area, including the historical Tertiary mine on the east bank and, in recent years, the Allstar mine on the west bank of the Fraser. The property was inactive when visited.

Section 9002

Location: West bank of the Fraser River, upstream from Cottonwood Canyon, approximately 18 kilometres northwest of Quesnel. The described exposure is illustrated in Figure 14B.

Unit	Height above base (m)	Description:
12	7.4 - 8.5	Medium to large-pebble gravel: poorly exposed; poorly sorted; lower contact gradational.
11	7.1 - 7.4	Interbedded sands and small-pebble gravel: planar crossbedding; lower contact gradational.
10	6.1 - 7.1	Medium to large-pebble gravel: poorly sorted; similar to Units 6 and 8; lower contact gradational.
9	5.8 - 6.1	Fine to medium sand: some coarse sand and granule beds; deformed bedding, some load structures and some original crossbedding; some coal fragments, especially concentrated in the upper 10 centimetres; lower contact gradational.
8	4.8 - 5.8	Medium to large-pebble gravel: massive to crudely stratified; poorly sorted; similar to Unit 9; some sand beds/lenses and scattered small (20 centimetres thick and 50 to 100 centimetres wide), horizontally laminated silt lenses; organics common, some lithified/silicified; as in all other units, gravel is oxidized (with red staining), especially around organics; moderately to well cemented; lower contact gradational.
7	4.5 - 4.8	Silt: weak horizontal laminae; very well sorted; some small fragments of organic matter; unit is a trough-shaped lens about 150 centimetres wide; lower contact sharp and horizontal. Sample 9022 (wood).
6	4.0 - 4.5	Medium to large-pebble gravel: crude horizontal bedding; beds are 1-4 centimetres thick; matrix filled with fine to coarse sand; minor trough crossbedded sand lenses (paleoflow to the east or southeast) 25-100 centimetres wide; lower contact conformable. Units 6 to 12 were measured about 30 metres upstream from Units 1 to 5. Cementation is stronger in Units 6 to 12, probably as a result of the more recent exposure (less weathering) of this part of the section face.
5	3.0 - 4.0	Interbedded fine to coarse sands and granular to small pebbly gravel: trough crossbedded; gravel forms trough-shaped lenses up to 2 metres wide and about 50 centimetres thick; beds are thin (1-3 centimetres); nonlithified organic fragments common in the upper part of this unit.

4	2.5 - 3.0	Small-cobble gravel: mostly cobbles, some large pebbles; unit has a crude trough shape with a scoured base; scours are up to 50 centimetres deep and 1-2 metres wide; clasts are subangular to subrounded; abundant quartzite; matrix varies from fine to coarse sand to only coarse sand; some beds with a fine sand matrix exhibit weak laminae; lower contact erosional. Pebble lithology sample 9021.
3	1.5 - 2.5	Medium to large-pebble gravel: massive to crude horizontal bedding; matrix fine to coarse sand; lacks imbrication; clasts are subangular to subrounded; weakly to moderately lithified; lower contact horizontal and gradational.
2	0.5 - 1.5	Large-pebble gravel: rare small cobbles; clast supported; gravel is poorly sorted; weakly to moderately lithified; crudely imbricated suggesting flow to the east-southeast; clasts subangular to subrounded; matrix filled with coarse sand; a lens of trough crosslaminated, fine to medium sand, 10 centimetres thick by 1 metre wide occurs in the centre of the unit; lower contact is sharp and erosional. Unit is poorly exposed, below high water level in spring.
1	0 - 0.5	Fine sands: some horizontal bedding and pebble beds; abundant muscovite and biotite flakes and organic fragments (reeds, sedges); moderately sorted; moderately well cemented; unit is trough shaped and thins laterally; lower contact covered. Sample 9020.
	Bedrock:	Interbedded shale and phyllite with interbeds of silicified siltstone and sandstone; two vertical joints strike at 170° and 080°; foliation (bedding?) dips 54°-58° toward 295°-305°; minor brecciation; strong oxidation; beds massive to strongly sheared and jointed; minor augen structures in schist/phyllite beds; bedrock is exposed along a road cut down to the river mine entrance over a distance of ~200 metres; the measured section is located near the mine entrance about 100 metres downstream (south) from the nearest bedrock outcrop. Section base is about 1 metre above river level. Note: Pebble lithology sample 9023 was taken on an upper terrace approximately 30 metres above the section.

SITE 3 - AHBAU CREEK

NTS: 93 G/1 Cottonwood
Latitude & Longitude: 53°11'N, 122°29'W
UTM: 5892500 m N, 533800 m E
Year of site visit: 1989

Site Description:

This site is located on the south bank of Ahbau Creek just upstream from its confluence with the Cottonwood River. Numerous recent exposures of oxidized gravels occur along the lower Cottonwood River and Fraser River near their confluence due to slumping and associated cut-bank erosion along both rivers. Recent exploration for Tertiary placers has been conducted in the area but there is no current mining activity. Although no detailed sections were measured, a general description of the lowermost gravel exposed along Abhau Creek is given below.

Section 8903 (Ahbau Creek Section)

Location: The Ahbau Creek Section is exposed along an east to northeast oriented cut-bank on the south side of Ahbau Creek, just upstream from the bridge on the old Highway 97.

Unit	Height above base (m)	Description:
2	10.0 - 15.0	Silts and sands: inaccessible; lower contact sharp and planar.
1	0 - 10.0	Medium to large-pebble gravel: horizontally bedded, well imbricated, weakly cemented. Clasts are mainly quartzites and cherts with minor (<5%) volcanics and rare plutonic and metamorphic clasts (in comparison with recent river gravel which has ~5% coarse igneous clasts as well as gneiss and schist). Observations of pebble imbrications indicate varying orientations of paleoflow. The lowest exposed gravels exhibit a paleoflow direction of 90°-150° (toward the southeast) whereas beds with well-developed imbrication higher in the sequence have a paleoflow of 240°-290° (generally west). Some planar crossbeds indicate a dip of 17° and an apparent dip direction of 060°. No coarse igneous rocks were found. There are some well-sorted sand beds, up to 20 centimetres thick, in the upper part of the section; lower contact covered.

SITE 4 - HORSEFLY RIVER

Hobson Horsefly mine
NTS: 93A/6 Horsefly
Latitude & Longitude: 52°24'N, 121°25'W
UTM: 5805500 m N, 608300 m E
Year of property visit: 1990

Site Description:

This minesite is located on a low terrace on the west bank of the Horsefly River. The deposit was first mined hydraulically and has more recently been worked by undergound mining methods. The measured section is the highwall remaining from the hydraulic operations. An adit is located at the base of the section and presumably follows the gravel-bedrock contact. Some continuous mining equipment is still present on the site.

Section 9004

Location: On a low terrace on the west side of the Horsefly River near Ratdam Lake (about 6 kilometres north of Horsefly townsite).

Unit	Height above base (m)	Description:
18	30.5 - 32.0	Diamicton: matrix supported; matrix silty with very little sand; about 30% clasts, more clasts toward the base; clasts mainly pebbles with a few cobbles and boulders; clasts subrounded to rounded, occasionally subangular (especially boulders); no striated clasts observed; quartzitic clasts common; matrix light brown colour; horizontal fissility; loose; lower contact gradational.
17	29.0 - 30.5	Diamicton with interbedded sand lenses: similar to Unit 18; lower contact gradational.
16	27.5 - 29.0	Medium to large-pebble gravel: minor cobbles; moderate to crude horizontal bedding; clast supported; moderately sorted; weakly oxidized; lower contact gradational.
15	26.0 - 27.5	Medium to large-pebble gravel: occasional large angular cobble; moderate to crude horizontal bedding; clast supported; moderately to poorly sorted; moderate to strong oxidation (iron); lower contact gradational.
14	21.0 - 26.0	Interbedded small to large-pebble gravel and sand: trough cross-stratified; gravel beds 40-130 centimetres thick; sand beds 30-70 centimetres thick; unit coarsens up overall; gravel is clast supported and moderately sorted; sandy beds well sorted; some scour-fill structures with cobble and pebble lags; lower contact gradational.
13	20.0 - 21.0	Medium to large-pebble gravel with some cobbles: massive to crude horizontal stratification; similar to Unit 5 below; lower contact gradational.
12	19.0 - 20.0	Sand and pebbly sand: unit is a trough-shaped sand lens; minor pebble beds.
11	17.5 - 19.0	Medium to large-pebble gravel: massive, poorly sorted gravel in lower 50 centimetres grading upward into moderately well sorted, horizontally bedded gravel (similar to Unit 4) in upper metre; lower contact gradational.
10	17.0 - 17.5	Sands: trough cross-stratified; unit is a lens about 5 metres wide, trough shaped with a flat top.
9	16.0 - 17.0	Medium to large-pebble gravel with some cobbles: massive to crude horizontal stratification; similar to Unit 5 below; lower contact gradational.
8	10.0 - 16.0	Small, medium and large-pebble gravel: low-angle, large-scale trough crossbedding; unit forms a trough about 25 metres wide; uncemented; gravel otherwise similar to Unit 4; lower contact erosional (scoured and crosscuts bedding in underlying units).
7	9.0 - 10.0	Medium to large-pebble gravel with some cobbles: massive to crude horizontal stratification; similar to Unit 5 below; lower contact gradational.
6	8.0 - 9.0	Medium to large-pebble gravel: horizontally bedded; similar to Unit 4 below; lower contact gradational.
5	6.0 - 8.0	Medium to large-pebble gravel with cobbles: clast supported; massive to crude horizontal stratification; poorly sorted; matrix filled with fine sand and coarser; moderate to strong carbonate cementation; prominent weathering pattern; lower contact gradational; (sample 9018).
4	3.25 - 6.0	Medium to large-pebble gravel: clast supported; horizontally bedded; beds 10-40 centimetres thick; matrix filled (with medium sand and coarser), moderately sorted, sandy, medium-pebble gravel is interbedded with openwork to matrix-filled, strongly oxidized (iron), large-pebble gravel; some bimodal, weakly imbricated to chaotic, large-pebble gravel beds with a medium sand matrix; some horizontally laminated fine to medium sand lenses; gravel is well imbricated; weakly lithified; clasts rounded to well rounded; paleoflow to the south (170°); pebble lithologies: vein quartz 20%, quartzite 20%, quartz gneiss 4%, chert 12%, mudstone/siltstone 8%, coarsely crystalline diorite 4%, (silicified porphyritic) basalt with olivine crystals 8%, rhyodacite/andesite (porphyritic, extrusive, green, grey, red) 24%; lower contact covered.
	1.75 - 3.25	Covered.
3	1.15 - 1.75	Small and medium-pebble gravel to small-pebble coarse sand: clast supported; unit fines upward; planar crossbedded (dip 20° to the NE - 050°); moderately sorted; subangular quartz and chert

		common in the upper sandy part of the unit; about 90% quartz and chert, some fine-grained green volcanics in the finer zones; well cemented; lower contact horizontal and gradational.
2	1.0 - 1.15	Medium to large-pebble conglomerate: clast supported with a medium to coarse sand matrix (in places silty); some small pebbles and a few cobbles; pebble lithology (sample 9016): vein quartz 32%, basalt 16%, quartzite 24%, chert 16%, porphyritic rhyodacite 4%, limestone 4%, mudstone 4%; moderately (to well) lithified; well cemented; reddish colour due to oxidation; lower contact erosional.
1	0 - 1.0	Siltstone, sandstone and shale: horizontally laminated; bedding generally dips at 35° to the south-southeast (160°); locally deformed; weakly lithified; organic beds common; some sulphur precipitate and iron oxide staining; less iron stained and more chloritic towards the top; other local bedrock exposures are in volcanic rocks (sample 9017); lower contact covered.

PRE-LATE WISCONSINAN (INTERGLACIAL) PLACERS PALEOGULCH SETTINGS (LOCATIONS 5 to 13)

(*See also* Location 21 [Sections 8921C and 9021] and Location 42 [Section 9042B]).

SITE 5 - RUCHEON CREEK (Larsen Gulch)

Owner/operator: Ron and Doris Drinnan
NTS: 93H/4 Wells
Latitude & Longitude: 53°09'N, 121°53'W
UTM: 5887600 m N, 576000 m E
Year of property visit: 1989

Site Description:

A small mining operation in this area is working poorly sorted, oxidized gravel at the base of a thick succession of sand and gravel. The active mine is at the head of a large hydraulic pit dating from the 1930s on Rucheon Creek, also known as Larsen Gulch. Figure 19A is a composite stratigraphic column of the two measured sections, with section 8905A at the base and 8905B forming the upper part.

Section 8905A

Location: This section is in deposits exposed by active mining in an artificial bank created by old hydraulic mining. (A stratigraphic column is provided in the lower part of Figure 19A.)

Unit	Height above base (m)	Description:
2	2.5 - 4.0	Granule to large-cobble gravel and diamicton: massive to weakly imbricated; matrix supported; clast fabric mainly appears chaotic; diamicton occurs as large unoxidized inclusions within oxidized gravel; lower contact gradational.
1	0 - 2.5	Granule to large-cobble gravel: horizontally stratified to massive; moderately to poorly sorted; some sandy interbeds; granule to medium-pebble beds alternating with large-pebble and cobble beds; clasts subangular to rounded quartzites, vein quartz, schists and gneiss; matrix is mostly sands with almost no silt; better sorted beds tend to be stained red-orange to purple by iron oxides and manganese; unit grades laterally into sandy gravel and gravelly sand; lower contact covered.

Section 8905B

Location: This section was measured in a large exposure at the head of the old hydraulic pit approximately 10 metres higher and 100 metres upstream from Section 8905A. (A stratigraphic column of this section is provided in the upper part of Figure 19A.)

Unit	Height above base (m)	Description:
5	19.85-21.35	Diamicton: massive except for vertical blocky jointing; matrix supported; matrix sandy silt; unit is thickest at the northwest end and is almost completely eroded in the southeast; 25% clasts; dominantly subangular to subrounded; commonly striated; numerous exotic clasts are present including serpentinite, carbonates and some igneous rocks, but most clasts are vein quartz, quartzites, gneisses or schists; lower contact indistinct. Sample 8920.
4	16.35-19.85	Fine to medium sands: at the southeast end of the section. Unit 4 consists of three beds: i) 50 centimetres of massive to crudely horizontally stratified fine to medium sands, overlain by ii) 50 centimetres of horizontally bedded sands 1-2 centimetres thick, overlain by iii) 50 centimetres of horizontally bedded fine sands; all beds grade to the northwest into more poorly sorted beds with pebbly sand interbeds and a capping diamicton; the upper part of the section at the southeast end has been eroded off; at the northwest end of the section, Unit 4 consists of (from the base up): a) 10 centimetres of massive, poorly sorted pebbly sand thickening to the northwest; conformably overlain by b) 50 centimetres of horizontally bedded, very well sorted, silt and fine sand beds (1-5 centimetres thick) with thin clay laminae; grading up into c) 25 centimetres of massive, poorly sorted, pebbly sands; d)15 centimetres of poorly sorted medium to large-pebble gravel with an erosional lower contact and a trough-shaped upper and lower contact;

		e) 100 centimetres of fine sands and silts with trough cross-bedding (channel-fill); f) 150 centimetres of massive, poorly sorted, pebbly sand with rare cobbles and trough-shaped lenses of sorted sand; lower contact covered.
3	15.85-16.35	Large-pebble gravel: crude horizontal stratification; crude imbrication; normal grading; clasts are dominantly large pebbles but range to medium cobble size; sorting is poor at the base where most cobbles occur, and is moderately sorted higher up. A thin 1-3 centimetre layer of manganese staining caps the unit; lower contact erosional (clear and planar and truncates underlying beds).
2	8.85 - 15.85	Pebble to cobble gravel: steep, large-scale (foreset) bedding; beds are normally graded and dip to the southeast at angles up to 35° (commonly 23° at the top of the unit decreasing to 15° near the base and in places almost tangential with the underlying unit); the lowermost bed consists of 2.2 metres of cobble gravel grading up into medium to large-pebble gravel (with a well-sorted sand matrix cobbles at the base grading upward into openwork gravel with some silt and clay skins), capped by 20 centimetres of small to medium-pebble gravel (openwork at the base and sandy in the upper part) and 10 centimetres of parallel-bedded, granular to small pebbly sands; foreset beds coarsen down-dip with an increase in cobbles (about 15% more) in the lower half; foreset beds are 1 to 5 metres thick; clasts are well rounded and pebbles near the top of the foresets are tabular and well imbricated; scattered outsized clasts occur throughout; lower contact erosional to locally conformable (undeformed bedding in sands around cobbles at the base of the unit suggests syndepositional sedimentation).
1	0 - 8.85	Fine to coarse sands: well stratified; ripple bedding, some horizontal bedding; beds are 2 to 10 centimetres thick with well-developed normal grading, coarsening upwards from coarse to medium sands at the base to fines at the top; beds internally have high-angle climbing-ripple, wavy, and horizontal laminae; some coarse sand to pebbly sand beds less than 1 centimetre thick with scoured bases; beds dip at 1 or 2° toward the southeast (150°); only 1 metre of the unit is exposed at the southeast end; at the northwest end of the section this unit consists of (from the base up): 150 centimetres of horizontally laminated silts and clays with minor fine sand beds; 5 centimetres of medium sand; 5 centimetres of silt and clay with abundant load structures; 50 centimetres of horizontally bedded silt and fine sand; 100 centimetres covered; 100 centimetres of horizontally stratified medium to coarse sand; 150 centimetres of ripple bedded silt and fine sand beds (2-5 centimetres thick) interbedded with horizontally stratified medium to coarse sands with minor flaser beds; 100 centimetres of horizontally bedded medium to coarse sands; 25 of centimetres medium sands and ripple-bedded silts; 75 centimetres of horizontally bedded sands and silts (10 centimetres pebbly sand, 5 centimetres silt, 10 centimetres pebbly sand, 20 centimetres coarse sand with silt interbed and 20 centimetres of coarse sand); lower contact covered.

SITE 6 - DRY-UP GULCH

Owner/operator: Boulder Gold Mines / Guy Carter
NTS: 93H/4 Wells
Latitude & Longitude: 52°03'N, 121°43'W
UTM: 5877500 m N, 5986700 m E
Year of property visit: 1989, 1990

Site Description:

This mine is on a small tributary of Chisholm Creek which flows into Lightning Creek. The present testing and geophysical exploration program is targeting bedrock benches on the valley side in which old drifts have been driven. The operators are developing a high-capacity processing plant including a large, circular, gravity separation system with long metal trays and a central pre-sized slurry feed.

Section 8906

Location: Small exposure in a test pit near the head of the old hydraulic pit.

Unit	Height above base (m)	Description:
1	0 - 4.0	Cobble to boulder gravel: clast supported; weakly developed bedding dipping down valley; silty sand matrix; very poorly sorted; poorly exposed; clasts up to boulder size; most clasts angular local schists but some rounded to subangular clasts also present, especially at the base of the unit; lower contact covered. Wood from an old shaft has been exposed by mining. The unit is probably colluvial in origin.

Section 9006

Location: Small exposure in a test pit near the base of Dry-up Gulch.

Unit	Height above base (m)	Description:
6	7.75 - 7.95	Silts and sands: Ah soil layer developed in unit; very finely laminated, horizontal and possibly some trough crosslaminae; lower contact gradational.
5	4.75 - 7.75	Sandy pebble diamicton: massive to very crude subhorizontal stratification; matrix supported; matrix fine to coarse sand with some silt; clasts up to small-cobble size; angular to subrounded clasts; loose and unconsolidated; some slightly better sorted strata are oxidized. In the upper metre there are some iron and manganese-stained, poorly sorted medium to large-pebble gravel beds (5-20 centimetres thick) interbedded with sandy diamicton; lower contact gradational.
4	4.25 - 4.75	Very fine sand and silt: horizontally laminated; very well sorted; lower contact gradational.
3	2.25 - 4.25	Fine sand with some medium sands: very finely laminated; horizontal and possibly some trough crosslaminae; minor wavy ripple bedding and deformation structures; very well sorted; lower contact gradational.
2	2.0 - 2.25	Fine sands with interbeds of angular, small to medium-pebble gravel and some coarse pebbly sand lenses: scattered clasts up to small cobble size; lower contact is sharp and horizontal.
1	0 - 2.0	Large-pebble to small-cobble gravel with some boulders: poorly sorted matrix of fine sand and up; minor iron oxidation; clasts are mostly subangular to subrounded with a few local angular clasts: pebble lithologies: 45% muscovite schist, 20% muscovite/quartz gneiss (commonly pyritized), 20% vein quartz, 10% quartzite and 5% metavolcanics or fine-grained metasediments; unit appears to be laterally discontinuous; possibly a gutter or channel gravel: lower contact undulatory.
	Bedrock:	Chloritic schist (to phyllite) with quartz veins and stringers: strongly fractured; some fractures filled with fine sand; foliation dips south at 60° (toward 180°); 1.5 metres exposed; the upper contact rises to the west.

SITE 7 - OLALLY CREEK

Owner/operator: Helen Lavender
NTS: 93 H/4 Wells
Latitude & Longitude: 53°05′N, 121°38′W
UTM: 5880800 m N, 591200 m E
Year of property visit: 1989

Site Description:

This small section is exposed in an exploration trench about 100 metres long on the north side of Burns Mountain. A number of shafts have recently been sunk in the area, including two in a narrow, deep gully (about 50 metres wide and 100 metres deep).

Section 8907

Location: This section was measured in an exploration trench located along Olally Creek about 1 kilometre from its mouth.

Unit	Height above base (m)	Description:
1	0 - 10.0	Pebble to large-cobble gravel: crude horizontal stratification; gravel is locally imbricated and poorly to well sorted; channel and scour structures also present; some well to moderately well sorted sand and pebbly sand interbeds; most beds are well oxidized to a red or orange colour; bedrock is not exposed; unit thickness varies with the exposure to less than 1 metre; lower contact covered.

SITE 8 - QUARTZ GULCH

Old hydraulic pit
NTS: 93H/3 Spectacle Lakes
Latitude & Longitude:53°03′N, 121°24′W
UTM: 5877500 m N, 606500 m E
Year of property visit: 1990

Site Description:

This section is exposed in an old hydraulic operation (Gold Run hydraulic pit) on the southeast side of Antler Creek. [Note: Maps by Johnston and Uglow (1926, p. 81) and Bowman (1895, map 367) show Quartz Gulch in the location of First Chance Creek as shown on modern maps]. This minesite is presently inactive.

Section 9008

Location: This section is located on the north side of the abandoned hydraulic pit.

Unit	Height above base (m)	Description:
3	7.0 - 10.0	Interbedded granular gravel and sand: some pebbly beds; sands well sorted; some bifurcated silty laminae about 2 centimetres thick; weak clast imbrication indicating paleoflow to the west; lower contact gradational.
2	3.0 - 7.0	Diamicton: crude horizontal stratification; matrix of sandy silt; 20 to 30% clasts, dominantly large pebbles with boulders up to 1 metre diameter; clasts occasionally striated; some laminated sand layers; one prominent sand bed, about 20 centimetres thick and 10 metres long dips 5-10° down-valley (west); some igneous clasts present; lower contact gradational.
1	0 - 3.0	Diamicton: massive; matrix supported; similar to Unit 2 except more matrix and striations on clasts more common; lower contact covered.

SITE 9 - BEGGS GULCH

Owner/operator: Bud Wilkinson
NTS: 93H/3 Spectacle Lakes
Latitude & Longitude:53°02'N, 121°25'W
UTM: 5875500 m N, 606300 m E
Year of property visit: 1989, 1990

Site Description:

The mined exposure at Beggs Gulch is located at road level about 50 metres northwest of the present stream which flows through the old, highly productive, hydraulic pit. Previous mining attempts at this site include a tunnel which extends from the present Beggs Gulch channel into the valley wall and several other tunnels on the northwestern side of the gulch. In 1989, the mining operation was targeting a possible buried channel of the stream. The section described below is overlain by about 3 metres of colluvial debris. Unit thicknesses are given as true thickness not vertical thickness (strata in Units 1 to 3 are nearly vertical).

Section 8909

Location: This section is located at road level approximately 50 metres northwest of Beggs Gulch.

Unit	Height above base (m)	Description:
2	3.0 - 6.0	Interbedded gravel and sand: horizontally bedded in the centre of the unit; some beds are laterally traceable into steeply dipping strata similar to underlying units suggesting a collapse structure; well-sorted fine to coarse sand beds and lenses (about 15 centimetres thick) exhibit thin horizontal laminae; angular-pebble gravel beds and lenses are 10-20 centimetres thick and nearly openwork; granule to small-pebble gravel beds are about 30 centimetres thick; some poorly sorted silt to small-cobble gravel beds; (a small test pit in this unit ~20 metres east of the active mine exhibits 2 metres of interbedded pebble gravel, moderately well sorted granule, and poorly sorted pebbly, trough-shaped sand beds dipping to the west) lower contact conformable. An old mine adit was driven at the base of this unit.
1-3	0 - 3.0	Due to their near vertical orientation, Units 1 to 3 are in lateral contact: true thicknesses of the units are given below in brackets:
3	(3.0)	Large boulder gravel (3.0 metres true thickness): boulders up to 2 metres diameter; mainly calcareous schist, phyllite and limestone; angular to subangular with some subrounded and rounded; clasts randomly oriented (some vertical); matrix is a mix of all grain sizes, 30% clay, silt and sand and the remainder small to large pebbles; small pockets/beds, 10-20 centimetres thick, of openwork medium to large-pebble gravel with a silty infiltration matrix occur locally beneath large boulders; clasts in these pods are angular schists, some rounded quartzites and some rounded, fine-grained, intermediate igneous clasts (greenstone); lower contact irregular.
2	(1.0)	Sandy pebble gravel, silty to fine sand diamicton and matrix-supported gravel: beds are near-vertical (true thickness is ~1 metre) and bed contacts are irregular; pebble gravel is clast supported, moderately to poorly sorted with angular to subrounded clasts of mixed lithology and beds 25-100 centimetres thick; diamicton beds are irregular in thickness (varying from 10 to 50 centimetres), matrix supported, with angular to subrounded clasts (dominantly schist and quartzite); matrix-supported gravel beds are very poorly sorted and chaotic with angular to subangular clasts (small to large pebbles and mostly schist with some siltstone, quartzite and vein quartz), matrix is silt to granules, minor openwork lenses; lower contact sharp and dips steeply to the west-northwest.

1	(4.0)	Fine to medium sand: some silt and coarse sand beds; horizontally laminated silt and fine sand; medium to coarse sands in beds and lenses; strata dip at angles up to 50° toward 300° (WNW) and are discontinuous (traceable for 1 to 2 metres); unit true thickness is ~4 metres; some massive beds; the unit grades upward into a large bouldery sand and becomes almost clast supported at the top; boulders are subrounded and are mostly veined limestone, with some schist, gneiss and quartz gneiss. In this upper area the sandy matrix is massive with occasional pods of sand and gravel (10 to 50 centimetres wide); lower contact covered. Bedrock was reported to be about 2 metres below the section base at the site of the mine exposure.

SITE 10 - STEVENS GULCH

Owner/operator: Stan Brewer
NTS: 93 H/3 Spectacle Lakes
Latitude & Longitude: 53°00'N, 121°25'W
UTM: 5874000 m N, 606000 m E
Year of property visit: 1990

Site Description:

The section is located on the south side of a small creek occupying Stevens Gulch, about 100 metres vertically above the road along Antler Creek. The section is in a small active open-pit mine along the southeast side of the valley wall.

Section 9010

Location: The section described is on the southeast side of Stevens Gulch and in the wall of an old hydraulic pit.

Unit	Height above base (m)	Description:
7	6.8 - 10.0	Sandy diamicton: massive; matrix supported; clasts up to cobble size; unit laterally is in contact with massive, fine sands with a sheared and slickensided lower contact; unit apparently has slumped.
6	6.3 - 6.8	Fine sands: irregular laminae; unit forms a weakly defined trough-shaped lens; lower contact undulatory.
5	4.8 - 6.3	Sandy small-pebble gravel: matrix supported; crude large-scale trough crossbedding with some better sorted gravel lenses; beds defined by sorting variability; beds are 10-25 centimetres thick and pinch out laterally; a large-pebble concentration occurs at the top of the unit; lower contact gradational.
4	3.3 - 4.8	Interbedded schistose breccia and fine sand: breccia beds are up to 50 centimetres thick and locally contain vein-quartz clasts in addition to schist; sands are horizontally bedded with beds ~1 centimetre thick; upper 50 centimetres of unit is dominantly sands; lower contact and all bed contacts gradational.
3	1.5 - 3.3	Very fine sands with diamicton interbeds: sands are finely laminated; diamicton interbeds contain abundant brecciated schist clasts, have a silty sand matrix, and occur as pockets or lenses in the sands; laterally this unit thins to less than 1 metre; near the valley wall the unit consists of interbedded sandy pebble diamicton and relatively well laminated clean fine and very fine sands with lenses and beds dipping about 13° to the north; the diamicton dominates in the north (closer to the valley side) whereas the sands are more prominent to the south; a bed with numerous local clasts of flat-lying quartzite occurs near the top of the unit; lower contact gradational.
2	0.5 - 1.5	Sandy, medium to large-pebble gravel: massive; fabric chaotic, not imbricated; poorly sorted; matrix filled with fine sands and coarser sediments; minor silt; clasts subrounded to rounded; some subangular and some broken bedrock pieces; some angular sandstone/quartzite clasts, extremely weathered (grussified); numerous green phyllite clasts and schists (local); pebble lithologies: 28% phyllite (some pyritiferous), 20% quartz gneiss, 20% muscovite schist (some pyritiferous), 12% metasandstone, 8% chlorite schist, 8% quartzite, 4% other gneiss; lower contact is sharp and undulatory and dips at ~20° toward the valley centre (north); the gravel contains approximately 11 grams of gold per cubic metre; most of the coarse gold nuggets observed were subangular to rounded with few being well rounded; 5 to 15-gram nuggets are common; the largest observed was about 60 grams; the pay zone rises and thins to the south, following the bedrock contact.
1	0 - 0.5	Bedrock: muscovite-quartz schist; breaks into angular blocky pieces interbedded with micaceous quartzite; bedrock rises to the south locally, about 1-2 metres rise over 5 metres; foliation dips 76° to the southwest (225°); upper contact is irregular.

SITE 11 - CALIFORNIA GULCH

Owner/operator: Stan Brewer
NTS: 93H/3 Spectacle Lakes
Latitude & Longitude: 53°00'N, 121°25'W
UTM: 5873500 m N, 606000 m E
Year of property visit: 1989

Site Description:

The site is located in an small active open-pit mine on the south side of a small creek occupying California Gulch, above Antler Creek. A stratigraphic column of the described section is given in Figure 19C.

Section 8911

Location: This section is a description of the main highwall of the mine which is cutting into a small bench (~30 metres high) on the south side of California Gulch.

Unit	Height above base (m)	Description:
7	11.0 - 13.0	Pebble to cobble gravel: matrix sandy; very crude horizontal stratification indicated by variations in clast size and sorting; locally almost openwork; poorly sorted to moderately sorted; clasts are subrounded to rounded; abundant schistose pebbles, flat and discoid shapes; cobbles and boulders mostly quartzite and gneiss; a concentration of cobbles and boulders occurs at the base of the unit; locally the lower part of Unit 1 has a moderately sorted granule to small-pebble gravel with weak horizontal stratification; lower contact is erosional (scoured).
6	10.5 - 11.0	Pebbly sand: massive; lower contact gradational.
5	8.5 - 10.5	Diamicton (probably colluviated till): massive; matrix supported; clasts are small pebbles to boulders, mostly medium and small pebbles with scattered cobbles; matrix varies in composition from a silty sand to a sandy silt with minor clay; some small horizontal partings dipping parallel to the slope; clasts mainly limestone (striated), gneiss, quartzite and schist; in the lower part of the diamicton there are sand lenses and trough-shaped, poorly sorted gravel lenses; lower contact varies from clear and planar to gradational.
4	5.5 - 8.5	Fine sands: some silts and minor clay; well-developed subhorizontal to horizontal stratification; beds are usually 0.3 to 1 centimetre thick and rarely up to 3 centimetres; beds grade normally upward from fine sands to silts and rarely into clay; rare gravelly lenses, 5 centimetres thick and 1 metre wide; lenses exhibit normal grading with small pebbles at the base grading up into granules and sands; granule beds, about 1 centimetre thick, are common in the lower half of the unit and commonly grade into sand beds; minor ripple structures and horizontal laminae; some of the coarser beds tend to be scoured at the base and beds are sometimes truncated by overlying strata; beds are commonly convoluted; faulting and microfaulting are common; faults are syndepositional, occurring within individual beds (interstratal or intraformational); slickenside surfaces are locally common; sands are clean and well sorted; conchoidal fractures; lower contact is unconformable, contact is clear and sand infiltrates into the gravel below.
3	2.5 - 5.5	Pebble gravel (90%) and interbedded coarse sands (10%): beds dip steeply to the northwest (335°) at 28°; in the upper 2 metres gravel beds are mainly poorly to moderately sorted medium-pebble gravel; some large-pebble and small-pebble beds; abundant schist; most clasts seem to lie parallel to bedding giving the unit a crude stratification; the matrix is mostly coarse sand with some fine and medium sand and no silt; gravel beds vary in thickness from 10-100 centimetres; thicker beds are poorly sorted with clasts up to small-cobble size but most clasts are flat discoid schists of medium-pebble size; sandy beds have some fine and medium sand and some pebbles; thin pebbly layers have weak inclined bedding; sandy beds are up to 20 centimetres thick and only a few sandy beds occur in the upper 2 metres; in the lower 1 metre, sand beds about 10 centimetres thick dominate; sands are well sorted with inclined parallel laminae; contacts between beds are all sharp; lower contact conformable.
2	2.25 - 2.5	Fine sands: parallel laminae; unit is partially covered and true thickness is not known; very well sorted; no pebbles; lower contact undulates irregularly.
1	0 - 2.25	Small-pebble to large-cobble gravel: some boulders (some large subrounded quartzites); clast supported; no stratification apparent; numerous flat-lying discs and blades; clasts are subangular to subrounded; sandy matrix (fine sands and silts mostly but some coarse sands and granules); clasts mostly schist, quartzite, quartz gneiss, phyllite and vein quartz; reddish brown colour; lower contact covered; unit underlies Units 4, 5 and 6 which are all inclined.

SITE 12 - NUGGET GULCH

Old hydraulic pit
NTS: 93 A/14 Cariboo Lake
Latitude & Longitude:52°58'N, 121°24'W
UTM: 5869500 m N, 606500 m E
Year of property visit: 1989

Site Description:

The section is located on the side of an old hydraulic pit in Nugget Gulch, a small tributary to upper Antler Creek. No current mining activity was observed and only a brief description of exposed deposits at the site is provided below.

Section 9012

Location: This section describes the stratigraphy on the north side of the old hydraulic pit.

Unit	Height above base (m)	Description:
4	25.0 - 30.0	Diamicton: massive; matrix supported; poorly exposed.
3	17.0 - 25.0	Pebble gravel with some sand lenses; horizontal bedding and planar crossbedding; sand lenses 1-2 metres thick; planar crossbeds (foreset beds), dipping steeply (~30°) to the west (280°) dominate a gravel bed 3 metres thick in the lower part of the unit.
2	10.0 - 17.0	Fine sands: horizontally laminated; some ripple bedding; some 1-2 centimetre graded fine sand beds; very well sorted; a medium-pebble gravel bed 1 metre thick occurs in the lower part of the unit with mainly angular to subangular tabular quartzite and siltstone (of local origin); beds laterally traceable for tens of metres; lower contact conformable.
1	0 - 10.0	Pebble gravel: horizontal bedding; clast supported; moderately well imbricated; moderately to poorly sorted; lower contact covered.

SITE 13 - BLACK CREEK

Owner/operator: Lyle Shunter
NTS: 93A/6 Horsefly
Latitude & Longitude: 52°19'N, 121°06'W
UTM: 5797000 m N, 630000 m E
Year of property visit: 1990

Site Description:

This property is located on Black Creek, a small southerly flowing tributary of the Horsefly River, about 25 kilometres east of Horsefly townsite. The mine is located at an elevation of about 990 metres on the south flank of Horsefly Mountain. The mine lies just upstream of a modern canyon, in places about 20 metres wide and 50 metres deep, with several sharp bends.

Section 9013A

Location: This section is located in a small glaciofluvial gravel terrace remnant on the west side of Black Creek.

Unit	Height above base (m)	Description:
1	0 - 3.0	Interbedded large-pebble gravel, coarse sand and granular to small-pebble gravel; horizontal to slightly inclined beds dipping to 290°, at up to 5°; subangular to rounded clasts; large-pebble gravel is poorly sorted; coarse sand and granular to small-pebble gravel is moderately sorted; some openwork small and medium-pebble gravel lenses; occasional spherical and well-rounded diamicton/mud clasts; clasts mainly fine-grained angular to subrounded, local siliceous bedrock; some vein quartz, black quartzites or cherts, quartzite and granite; lower contact covered.

Section 9013B

Location: This section is located along the east side of Black Creek.

Note: The description of the lowermost 7.5 metres is taken from drillers logs of a hole located where the mine road crosses Black Creek. The drill-hole and section data overlap from 7.5 metres to 20 metres above the base.

Unit	Height above base (m)	Description:
16	25.0 - 30.0	Diamicton: matrix supported; massive; 20-30% clasts; numerous cobbles and boulders, mainly subrounded to rounded; some striated clasts; matrix is a silty sand; unit thickens to the south; lower contact covered.
15	24.1 - 25.0	Covered.
14	23.1 - 24.1	Coarse cobble gravel: fines upward into a small-pebble gravel; clast supported; nearly openwork; clasts are subrounded to well rounded in contrast to mainly angular to subangular or subrounded clasts in underlying units; some pebble-cobble clusters; lower contact scoured, up to 1 metre deep and 3 metres wide.
13	22.7 - 23.1	Fine sand: trough-shaped lens; parallel laminae; conformable lower contact.
12	22.6 - 22.7	Large-pebble to small-cobble gravel: poorly sorted; lower contact erosional, trough-shaped and scours into the underlying two units (22.1-22.6 m and 22.6-23.1 m).
11	22.6 - 23.1	Small to medium-pebble gravel: planar crossbedded; well sorted; mainly openwork; beds dip northerly at the north end of section and southerly at the south end; The overlying two units cut down into and infill a trough in this unit. Lower contact is sharp and slightly erosional.
10	22.1 - 22.6	Fine sands and minor silt: parallel laminations and some ripple (wavy) bedding; well sorted; lower contact sharp and dips gently to the northwest. Unit thickens up-dip to almost a metre.
9	22.0 - 22.1	Large pebble-cobble gravel: horizontally bedded (top-set beds); unit is a lens and thickens down dip; partially openwork and partially filled with granules and coarser; lower contact erosional.
8	20.0 - 22.0	Granular to medium-pebble gravel with interbedded large-pebble gravel: large-scale planar crossbedding (foreset beds as above); weakly developed normal grading in coarser gravel beds; moderately to well-sorted; finer gravel mostly openwork; large-pebble gravel bimodal with a fine sand matrix; some cobbles near unit base; beds are 10 to 40 centimetres thick and coarsen down dip; lower contact conformable.
7	18.0 - 20.0	Large-pebble gravel: crude bedding dipping 21° to the north (020°); matrix (bimodal) is fine sands; pebbles are mainly angular to subangular; gravel is poorly sorted; lower contact is sharp and dips to the north.
6	14.0 - 18.0	Very fine sands and silts: mostly fine to medium sands with silts; in the upper metre there are some coarse sand beds; fine parallel laminae; minor climbing ripple laminae; laminae internally graded, (normal grading, rarely inverse); laminae contacts are weakly scoured in places but mostly gradational; overall this unit coarsens upwards; beds dip at 20° towards the east (110°); very well sorted; lower contact conformable.
5	8.0 - 14.0	Sandy clay: parallel laminae; unit coarsens downward into medium sands in the lower 50 centimetres; bedding dips at 33° north (010°); very well sorted; sharp lower contact.
4	7.5 - 8.0	Medium-pebble gravel: massive; fines upward from a large-pebble to a coarse granular small-pebble gravel; moderately to well sorted; subangular to well-rounded clasts; minor openwork; lower contact covered.
3	5.0 - 7.5	Clay and gravel (drill-hole data).
2	2.0 - 5.0	Wet gravel and clay (drill-hole data).
1	0 - 2.0	Clay (drill-hole data).
	Bedrock:	Fine-grained silicified basalt (?); locally cut by coarse-grained porphyritic feldspathic intrusives.

ABANDONED PALEOTRUNK-VALLEY SETTINGS (LOCATIONS 14 TO 22)

SITE 14 - ALICE CREEK

Owner/operator: Soaring Resources Ltd.
NTS: 93G/1 Cottonwood
Latitude & Longitude:53°05'N, 122°05'W
UTM: 5881200 m N, 561700 m E
Year of property visit: 1989

Site Description:

This large open-pit mine is located on the east side of Alice Creek approximately 0.5 kilometre upstream from its confluence with John Boyd Creek, a tributary of the Cottonwood River. The mine is about 3 kilometres northeast of Cottonwood. The property was inactive but several good exposures were present due to open-pit mining in 1986. A composite stratigraphic section is given in Figure 26A and a location map is provided in Figure 24.

Section 8914A (South Wall Section)

Location: This is a composite section measured along a series of highwall exposures on the south side of the mine. Most of the measured sequence is overburden.

Unit	Height above base (m)	Description:
17	30.0 - 31.0	Diamicton: matrix supported; loosely consolidated; matrix sandy silt; 15% clasts, pebbles, but no cobbles or boulders; horizontal fissility especially well developed in top 50 centimetres; abundant roots and organics; poorly developed Ah and Bf in the top 20 centimetres; Cca throughout the unit; upper surface has quartzite clasts on it; lower contact is gradational.
16	24.0 - 30.0	Diamicton: massive and compact; sandy silt matrix; ~20% clasts, mostly small and medium pebbles, a few large pebbles and cobbles; clasts are subangular to subrounded and commonly striated; pronounced vertical joints, spaced 10-20 centimetres apart, often have roots in them and are stained black-purple; jointing and staining in unit are less prominent in lower 1 metre; unit traced laterally for 40 metres; there are few sorted layers; diamicton is sandier towards the base and in places there are 40-50% clasts; pebble lithologies: 30% mafic igneous, 25% quartzite, 13% diorite, 8% slate, 8% vein quartz, 8% gneiss, 4% rhyolite, 4% granite, sample taken throughout unit; diamicton sample 8963, taken at 25.7 metres; lower contact is poorly defined but is usually gradational, locally marked by beds of irregularly laminated sands and silts with pebbles or by slickensided, massive clay and silt beds; it is sometimes marked by a fine sand bed 1 centimetre thick that can be traced laterally for over 10 metres.
15	21.0 - 24.0	Diamicton: sandy to silty clay matrix; diamicton beds separated by 1-20 centimetre sand, silt and clay beds; diamicton beds 1-2 metres thick dominate and show some internal clay laminations and crude stratification defined by increased clay content and enhanced by sorted lenses and slickensided surfaces; beds pinch out laterally and interfinger with clay, silt and sand beds; one sorted bed is most obvious, it is 10-50 centimetres thick, has a thin silt layer overlain by a crudely laminated sand bed and capped by clay and silt, is laterally traceable for 20 metres; the upper contact is interfingered with thin diamicton beds less than 2 centimetres thick and stringers of fine sand, silt and clay; the lower contact is gently undulatory and has numerous load structures on the lower silt layer, clay-silt sample 8962; other clay beds are lens shaped, mostly with a flat base and convex top; clay-silt beds are strongly tectonized (slickensides and polished surfaces), occasional clasts incorporated, clay beds are 10-30 centimetres thick and break into blocks along polished surfaces, clay lenses are bounded by pronounced slickensided surfaces; slickensides on horizontal surfaces trend at 170-190°; fine to medium sand lenses are trough shaped, beds are 2 to 20 centimetres thick and 1-3 metres wide and tend to be horizontal; the lower contacts are sharp and loaded, they have crudely deformed bedding and some scattered pebbles; normal faulting is commonly visible across the sorted lenses; diamicton and clay lenses are sometimes in near-vertical contact or are complexly interfingered; lenses or small clasts of diamicton occur within clays suggesting simultaneous shearing; sand lenses between clay lenses are also thrusted and sheared; unit is trough shaped.
14	16.5 - 21.0	Sandy diamicton: massive; ~15% clasts, ranging to 40%; matrix is silty sand; lower contact is gradational.
13	15.5 - 16.5	Diamicton: matrix supported; matrix of fine sands; horizontally stratified; stratification is visible through slight textural variations, silty or coarser sandy layers, silty layers are darker, layers are 5-15 centimetres thick; stratification is due to horizontal concentrations of silt and clay intraclasts, intraclasts layers are 0.2-2 centimetres thick; 10% clasts, some striated; some large intraclasts up to

		3 centimetres in diameter occur within thicker diamicton beds, some intraclasts have internal laminations; lower contact is sharp and gently undulating and dips at a low angle to the east.
12	12.75 -15.5	Interbedded sands and gravels: only the top metre and bottom 50 centimetres exposed; well-sorted sands are coarse to very fine; abundant coarse beds are 10-20 centimetres thick, strongly oxidized; rarer fine beds are less than 1 centimetre thick; beds exhibit thin horizontal laminae; sands occur in a lens-shaped body which is laterally interbedded with gravels; gravels are small pebbles to small cobbles, subangular to rounded; crude horizontal bedding, some crude imbrication and crude normal grading; the lower 50 centimetres of the unit has interbedded sand and gravel beds; pebble lithology sample 8939 taken at 17.75 metres, 32% quartzite, 28% quartz gneiss, 12% vein quartz, 8% siltstone, 4% sandstone, 4% micaceous sandstone, 4% gneiss, 4% mafic igneous; lower contact is sharp and undulatory.
11	6.75 -12.75	Diamicton: matrix supported; matrix of silty sand; compact; stratification imparted by colour banding and textural variations, based on changes in clast content; beds are 10 to 200 centimetres thick; some basal contacts of beds are slickensided (265-270°); one bed 1-5 centimetres thick can be traced for 15 metres, ~5% clasts, has a sharp contact defined by a clay-silt concentration 1-2 millimetres thick; 20-40% clasts, small to large pebbles and rare cobbles, subangular to subrounded, striated clasts common; massive with iron staining along joints in the upper part; clasts are more concentrated near the base, up to 30%; matrix is more clay rich toward the base; diamicton sample 8938 taken at 8.45 metres; lower contact is sharp and horizontal to gently undulatory.
10	6.45 - 6.75	Fine to medium sands: well sorted; large-scale trough crossbeds (channel-fill bedding) and horizontal beds, 2-15 centimetres thick; rare silty beds, 1-2 centimetres thick; unit thickens to 50 centimetres to the east and pinches out to the west; unit is laterally traceable for 10-15 metres; thrust faulting common; lower contact is trough shaped and clear.
9	5.3 - 6.45	Diamicton: matrix supported; silty sand matrix; massive; some horizontal parting; vertical jointing well developed, iron stained and widely spaced; some better sorted pockets, fewer pebbles; some lenses of poorly sorted sand occur near the base of the unit, lenses are 1 centimetre thick by 10 centimetres wide; there is also a horizontally laminated lens of well-sorted fine sand and silt, 15 centimetres thick by 2 metres wide; rare pebbly gravel lenses; clasts mainly small to medium pebbles with rare large pebbles and cobbles, angular to subrounded, striated clasts common; striae on the upper surface of one faceted and embedded clast trend from 000° to 035°, with an older set trending at 090°; clast content increases toward base to as high as 40%; plano-convex sand lenses occur at the base of the unit (*see* Unit 8); diamicton of Unit 9 occurs where sand lenses in Units 8 and 10 are absent; lower contact is gradational.
8	4.8 - 5.3	Fine sands and silts: unit occurs as a plano-convex lens about 3 metres wide; horizontal laminae at the base and weak planar crosslaminae in the middle of the unit; massive sands at the top with inclusions of diamicton and sandy small-pebble gravels; upper contact of the lens is gradational and locally interbedded with the overlying diamicton; laterally this unit consists of fine to medium sand beds with discontinuous horizontal strata (less than 20 centimetres long) and less than about 3% clasts; these sand beds exhibit pervasive thrust faulting and subhorizontal shearing and locally appear brecciated; pronounced iron staining, especially in medium sand beds; lower contact is sharp and planar, erosional.
7	3.6 - 4.8	Fine and medium sands: well sorted, mainly massive; weak horizontally laminae in lower part of the unit; locally pervasive thrust faulting; deformation decreases towards base of unit; sandy diamicton lenses are locally present with 5-50% clasts up to large pebbles; diamicton lenses are trough shaped, have erosional bases and contain sandy beds up 15 centimetres thick with gradational bed contacts; a discontinuous, horizontal, volcanic ash bed, 1-5 centimetres thick, occurs at 4.55 metres (sample 8927); lower contact of unit is sharp and undulatory.
6	2.8 - 3.6	Fine sands: very well sorted beds, 2-10 centimetres thick; massive, faint horizontal to irregular laminations, especially in lowest 30 centimetres, some trough crossbeds; unit has unoxidized laminae 2-3 millimetres thick that can be traced into normal faults in the underlying unit, laminations are close to horizontal toward the base; lower contact is horizontal and clear.
5	1.8 - 2.8	Fine to medium sands with silts: horizontally bedded, 3-5 centimetres thick with thin internal laminations; fine sand laminae are 0.5 centimetre thick; silty laminations are grey and up to 1 centimetre thick, often loaded; sandy beds are possibly rippled; normal and thrust faults; deformed beds common, convolutions and boudinages; some loading and fluid-escape structures; the basal 10 centimetres has scattered pebbles; lower contact is usually sharp, dips to the northeast (030°) at 25-30°, sometimes interfingered with underlying units.
4	1.0 - 1.8	Pebble and cobble gravel, poorly to moderately sorted: rare boulders; clasts are angular to well rounded, coarser clasts angular to subangular, pebbles tend to be rounded; some openwork pebble lenses where pebbles act as matrix to cobble gravel; crude inclined to horizontal stratification; weak imbrication, suggests flow to the south, tabular and disc-shaped clasts tend to lie flat; no silt or clay, 10% sand, 50% pebbles, 40% cobbles; cobbles and large pebbles are mafic igneous intrusives of local origin; strongly oxidized; pebble lithology (sample 8933), 28% mafic igneous, 16% vein quartz, 16% gneiss, 16% fine sandstone, 16% schist, 4% rhyolite, 4% mudstone; upper contact is interbedded with sands, gravel stringers extend into the sands; the lower contact is sharp and erosional, dips to the north, scours are 10-20 centimetres deep and 1-5 metres wide.
3	0.75 - 1.0	Fine and very fine sands: very well sorted; coarsens toward the base; horizontal bedding, 1-5 centimetres thick; sands are white (tephra?) to olive yellow, possibly bentonitic; stratification is

		marked by thin oxidized (reddish) laminae; sand sample 8934; lower contact is sharp and planar, conformable.
2	0.25 - 0.75	Coarse to fine sand with silt: well bedded and unit fines upward; top bed is a silty fine sand 4 centimetres thick with scattered granules, underlain by a fine to medium sand bed 5 centimetres thick with granules and pebbles, underlain by 2 centimetres of fine sand with scattered pebbles and at the base a horizontally bedded fine, medium and coarse sand bed 40 centimetres thick; basal bed has fine and medium sand beds 1-5 centimetres thick interbedded with coarse sand beds 1-5 centimetres thick, beds are lens shaped and often loaded; strongly oxidized; the unit is trough shaped, pinches out to the south; lower contact is clear, horizontal and conformable.
1	0 - 0.25	Pebble gravels: crudely horizontally stratified; clast supported; clasts up to large pebbles; poorly to moderately sorted; matrix of sand and silt; clast imbrication suggests flow to the south; heavy iron staining (orange-purple) and some manganese staining (black); pebble lithology (sample 8935), 16% quartz gneiss, 16% schist, 16% vein quartz, 8% gneiss, 8% shale, 8% mudstone, 8% mafic igneous, 8% quartzite, 4% sandstone, 4% chert, 4% ironstone; lower contact is covered.

Section 8914B (North Wall Section)

Location: Composite section measured along a temporary mine road in the northern part of the mine.

Unit	Height above base (m)	Description:
14	12.75-18.0	Diamicton: matrix supported; dense; matrix of sandy silt; 10% clasts, mainly small to medium pebbles, some large pebbles, few cobbles and rare boulders; clasts subangular to subrounded; striated clasts common; clasts tend to lie flat; vertical jointing 10-30 centimetres apart; at 1.5 metres there is a lens of horizontally laminated fine sand, silt and clay 20 centimetres thick; lens is 3 metres wide and is laterally interbedded with diamicton; slickensides on clay surfaces on top of the lens trend at 350°, lower contact of lens is gradational; fine sand content increases lower in this unit; lower contact is interbedded.
13	10.95-12.75	Silts and clays interbedded with very fine sands, diamicton, coarse sand and pebbles: silts and clays are horizontally laminated, in places they are massive and sheared with slickensides that dip up to 25° and trend 180°; fine, medium and coarse sands are laminated and locally have injection structures; scattered clasts occur in the sand and silt beds; small pebbles and mud balls occur in laminae; clay and silt laminae are thinner and more common to the west; beds thicken and coarsen toward the east, grading into diamicton; sand beds are up to 30 centimetres thick, mostly less than 5 centimetres; coarse sands are restricted to lenses about 1 metre wide; pebbly beds are lens shaped, 1 metre wide and 10 centimetres thick; ~10% clasts; diamicton beds are up to 10 centimetres thick, traceable for over 5 metres, have subhorizontal, undulatory and loaded lower contacts; diamicton increases gradually to the southeast, laterally interbedded with sands and silts; sand, silt and clay content increases to the west; normal faults common, displacements of 5 centimetres; lower contact of unit is clear and planar, appears erosional.
12	10.45-10.95	Large-pebble gravel and diamicton: poorly sorted gravels; clasts range from small pebbles to small cobbles; clasts are subangular to subrounded; clast supported with a matrix of fine to medium sand, abundant muscovite flakes; locally moderately sorted, openwork medium-pebble gravel; unit is highly variable with inclusions of sand and some pockets of very poorly sorted gravel (almost matrix supported); some concentrations of angular local bedrock (quartzite); chaotic fabric; irregular trough-shaped lens ~15 metres wide; gravels are oxidized, reddish coloration; to the southeast the gravels are partially eroded by a lens of diamicton, gravels underlie the diamicton lens; diamicton matrix of sandy silt, dense, has 10% clasts; lower contact of diamicton is sharp, erosional and irregular; slickensides trend 170°; some interbedded sand lenses; pebble sample 8942; lower contact of unit is highly irregular, unit thickens to the southeast and pinches out to northwest.
11	9.95 - 10.45	Fine sands: well-sorted; deformed laminations, beds tilted, normally faulted and some thrust faults, deformation increases toward the top of the unit; primary stratification is horizontal laminae at the base and trough crosslaminations toward the top; red oxidation; lower contact is gradational.
10	6.5 - 9.95	Fine sands and silts with clays: sand beds are up to 5 centimetres thick, silts beds are up to 2 centimetres thick and clay beds are less than 1 centimetre thick; scattered pebbles throughout the unit, some show penetrative deformation of underlying beds and draping over clasts; clasts are up to medium pebble size; some ironstone concretions to medium pebble size; beds thicken toward the top of the unit; sandy beds are normally graded, some thicker beds are (trough) crosslaminated; individual beds have loaded lower contacts and are commonly crosscut by normal faults (displacement of 0.1-5 centimetres); beds dip northwest at 10-22° toward 310-320°; steep dip of beds is due to multiple thrusting events which offset and displace cumulatively; beds are readily traced across most faults; an older set of faults dips southeast and is crosscut by the later northwest-trending set; fault movement is rotational (scissor-like), at the hinge displacement is less than 1 centimetre and up the axis can be as much as 20 centimetres; low-angle thrust faulting produces recumbently folded strata; thicker beds of clay act as detachment zones on the fault; a prominent set of thrust faults dips ~14° to the north and a secondary set dips ~20° south; displacements are up to 10 centimetres; thrusted strata are stacked onto each other; vertical

		displacement can be up to 30 centimetres by cumulative deformation; deformation is least in the basal metre of the unit; lower contact of unit is gradational.
9	5.5 - 6.5	Very fine and fine sands with some silts: horizontally stratified beds 1-3 centimetres thick with laminae 0.1-1 centimetre thick; well to very well sorted; silt and fine sand beds have weak internal laminae; coarser sand beds tend to be thinner (<0.5 centimetre) and finer beds are thicker (>1 centimetre); some normal grading and minor reverse grading; iron (red) and manganese (black) staining on some laminae; lower contact is clear, planar and conformable.
8	4.8 - 5.5	Fine sands: thickly bedded (>10 centimetres) with internally parallel laminae and some silt laminae; lower 30 centimetres of unit is trough crosslaminated (beds 3-7 centimetres thick); lower contact is gradational.
7	4.2 - 4.8	Fine sands and silts: horizontally bedded with thin internal laminations; in the top 30 centimetres beds are 3-8 centimetres thick with some normal grading; lower 20 centimetres is trough crossbedded fine sands with horizontal silt beds; some soft-sediment deformation (loading and injections); sandy beds are generally thicker, up to 10 centimetres, while silt beds are 1-2 centimetres thick; unit fines upward; lower contact is gradational.
6	3.7 - 4.2	Fine to coarse sands with granule and pebble beds: trough crossbedded gravel and sand beds are 1-20 centimetres thick by 0.1-1.5 metres wide; troughs fine upward from granular gravels to fine sands, trough centres and tops are finer; iron and manganese staining is common in coarser beds, some manganese cementation; unit generally fines upward; lower 10-20 centimetres is horizontally bedded coarse sand and fine gravels (beds are 3-5 centimetres thick) with internal laminations; lower contact is sharp and planar, mostly erosional with some scouring.
5	3.4 - 3.7	Fine sands and silts: unit generally fines upward; beds 2-7 centimetres thick; top 10 centimetres has horizontal to wavy laminae, lower 20 centimetres is wavy to trough crosslaminated; oxidized in the lower 5 centimetres; lower contact is clear and slightly undulatory, depositional.
4	2.5 - 3.4	Medium-pebble gravel: ranges from granule to large pebbles, rare cobbles; clasts are angular to subrounded; matrix of medium sands to granules; unit is trough shaped with crude subhorizontal beds mostly 5-10 centimetres thick; unit fines upward; medium-pebble beds have a fine to coarse sand matrix; some well-sorted and more oxidized openwork beds of small pebble gravel; some granular beds with medium to coarse sand matrix; coarser beds are poorly sorted; most beds are moderately sorted and have minor oxidation; a large pebble-cobble gravel occurs at the base of the trough; lens pinches out to the northwest and thickens to the south; truncated contact to the northwest as this trough is crosscut by a second coarse gravel lens which contains large pebbles and some cobbles, is planar stratified and has better sorting and rounding; pebble lithology (sample 8941), 24% vein quartz, 22% schist (14% muscovite-quartz schist, 6% quartz-biotite schist, 2% other schist), 14% mafic igneous, 12% quartzite, 10% quartz-biotite gneiss, 6% quartz gneiss, 6% siltstone, 4% intermediate volcanics, 2% chert; sample taken at 15.0 metres depth; lower contact is trough shaped, sharp and erosional.
3	1.5 - 2.5	Fine sands and silts: lens shaped with large-scale trough crossbeds, beds 1-5 centimetres thick with fine internal laminations, traceable for 5 metres; unit fines upward from fine sands at the base to silts at the top; contains two prominent beds of white volcanic ash 1 centimetre thick, located 20 and 25 centimetres above the base of the unit, the lower bed is prominent and has parallel laminations; ash sample 8937 taken at 1.7 metres, sand sample 8940.
2	1.0 - 1.5	Small to medium-pebble gravel: inversely graded unit; poorly sorted; crude planar bedding, 1-5 centimetres thick; some thin sandy beds; clasts are weakly imbricated; lower part of bed is a pebbly sand with 5-50% pebbles, pebble content decreases to north.
1	0 - 1.0	Medium sands and pebbly sands: some irregular lenses of small-pebble sandy gravel; sands well sorted except for scattered pebbles; beds are contorted and irregular; lower contact is covered.

SITE 15 - MARY CREEK

Owner/operator: Terry and Gary Toop
NTS: 93G/1 Cottonwood
Latitude & Longitude:53°05′N, 122°05′W
UTM: 5883500 m N, 562000 m E
Year of property visit: 1989, 1990

Site Description:

This mine is located along Mary Creek, directly upstream from its confluence with Alice Creek. The mine is about 3 kilometres northeast of Cottonwood. The property is active and several good exposures occur both in current and old pits. The mine is located in a meltwater channel.

Section 8915A

Location: This section is approximately 50 metres south of Mary Creek about 250 metres east of the Toop residence (Figure 24).

Unit	Height above base (m)	Description:
4	4.0 - 5.2	Very fine, fine and medium sands and silts; well sorted; sand beds are well bedded, 1-3 centimetres thick, with thin (<1 mm) internal laminations; some massive, medium-sand beds; silty beds are most prevalent near the middle of the bed; some pebbly gravel beds, 5-10 centimetres thick and continuous for 2-5 metres, moderately sorted, small pebbles with a matrix of fine to medium sands; oxidation is strong near base, weakens upward, defines bedding contacts; normal faulting common; lower contact is gradational.
3	3.5 - 4.0	Very fine, fine and medium sands and silts: well bedded and sorted; loaded contacts; lower contact gradational.
2	3.0 - 3.5	Pebble to cobble gravel: matrix of fine to coarse sands; horizontally stratified; ~70% clasts, rounded to subrounded; beds of sand 1-3 centimetres thick; lower contact is gradational.
1	0 - 3.0	Diamicton: matrix supported; silty matrix with some clay, coarsens upward into silty sand; appears massive, no fissility or partings; 30-40% clasts, mostly small pebbles to small cobbles, large cobbles and boulders rare; clasts are subangular to subrounded; less clast rich at the base, coarsens upwards; breaks into 3 to 8-centimetre blocks of very compact diamicton; some clasts crumble or shatter when struck; striations are rare; colour changes up through unit, darker brown near base and reddish brown near top; fabric numbers 891505, 891505a and 891505b, 891505a taken at 2 metres, 891505b taken at base of exposure; lower contact covered.

Section 8915B

Location: This section is located on the same highwall as Section 8915A but approximately 50 metres farther west (Figure 24).

Unit	Height above base (m)	Description:
7	9.0 - 17.0	Diamicton: matrix supported; matrix of silty sand and clay; some poorly developed parting; colour and matrix textural variations produce layering near the base, light brown silty sand matrix layer, dark brown sand with silt layer, blackish brown silty sand layer; 25% clasts, subangular to subrounded, mostly small pebbles, some medium pebbles and rare larger pebbles, cobbles and boulders; stratification is visible throughout the unit; smeared reddish clasts are visible, probably partially lithified sandstones; clasts are sometimes striated; lower part of unit is compact and upper area is moderately consolidated; thin, discontinuous stringers or wisps of sand more than 1 millimetre thick; vertical jointing is common, especially well developed in the upper 2-3 metres; lower 10-20 centimetres is interbedded with sands and gravels, crudely interstratified; diamicton sample 8914 taken at 12 metres; fabric numbers 891506, 891506a, 891506b and 891507, 891506a taken at 9.5 metres, 891506b taken at 11 metres and 891507 at 12.5 metres; lower contact is gradational.
6	8.5 - 9.0	Fine and medium sands: crude stratification; occasional pebbly lenses have 10-30% clasts; rare folding, suggests compressive deformation; upper contact often has fingers of diamicton extending down into it, some sands also appear squeezed up into the diamicton; lower contact is depositional.
5	7 - 8.5	Diamicton: matrix supported; matrix of fine and medium sands; compact; breaks into small (1-3 centimetres) blocks along partings which are commonly oxidized; discoloration present throughout unit but strongest on joints; 10-20% clasts, to large-pebble size, mostly small pebbles, subrounded; lower contact is erosional.
4	6.0 - 7.0	Medium and fine sands with pebbly lenses: well bedded, 1-3 centimetres thick; weakly oxidized; lower contact is depositional.
3	5.5 - 6.0	Coarse sand and pebbly sands: 10-40% clasts, small and medium pebbles with rare cobbles, subangular to well rounded, mostly subrounded; unit grades normally upward; moderate oxidation; sand sample 8913 taken at 5.6 metres; lower contact is gradational.
2	5.0 - 5.5	Small-pebble to cobble gravel: clast supported; more than 70% clasts, subangular to well rounded, mostly subrounded; matrix of coarse sands; strongly oxidized, red coloration; moderate imbrication suggests flow to the west; pebble lithologies (sample 8912) 26% quartzite, 24% vein quartz, 16% schist, 15% gneiss, 11% igneous, 6% siltstone, 2% slate, taken at 6.1 metres; lower contact is erosional, possibly a lag deposit in the lowest 10 centimetres.
1	0 - 5.0	Diamicton: matrix supported; matrix is a silty fine sand with clay; 30% clasts, small pebble to large cobble, subangular to well rounded, mostly subrounded; breaks into 1-5-centimetre blocks; compact; no fissility or partings; no stringers or lenses of sand; at the base a slickensided clay layer dips 12° toward 088° and is correlated into section 8915C; red-brown colour; diamicton sample 8911 taken at 4.5 metres, diamicton sample 8910 taken at base of section; lower contact covered.

Section 8915C

Location: This section is located on the same highwall as Sections 8915A and B but is approximately 50 metres west of 8915B (Figure 24).

Unit	Height above base (m)	Description:
5	4.3 - 5.8	Diamicton: matrix supported; massive; sandy matrix; 30% clasts, small to medium pebbles, rare cobbles, subangular; contains sand and gravel lenses, about 10 centimetres thick, which dip towards 240° at 25°, sand lenses are well sorted, gravel lenses are moderately sorted; contacts with lenses are sharp and irregular; some subhorizontal fine sand laminations in the upper 50 centimetres, up to 2 millimetres thick and 1 metre long; lower contact is gradational.
4	1.7 - 4.3	Diamicton: matrix supported; massive; silty sand matrix; 30% clasts, small to medium pebbles, rare cobbles, subangular; lower contact is gradational.
3	1.6 - 1.7	Diamicton: matrix supported; massive; clay, silt and sand matrix; 30% clasts, small to medium pebbles, rare cobbles, subangular; numerous, irregular, very well sorted fine sand laminations, mostly subhorizontal, 1-2 millimetres thick and 10-20 centimetres wide, mostly in the bottom 3 centimetres of the unit; upper contact is bounded by a sharp, planar layer of laminated clays that dip at 20° towards 240°, no observable slickensides but there are small fractures which extend from the clay layer upward into the overlying diamicton, these dip at 21-38° toward 160°; the zone between the fracture and these clay layers consists of brecciated clays, resembling a number of thrusted platelets, some of which are slickensided; lower contact is planar and diffuse.
2	1.5 - 1.6	Diamicton: matrix supported; massive; sandy matrix, some silt; 30% clasts, small to medium pebbles, rare cobbles, subangular; lower contact is planar and diffuse.
1	0 - 1.5	Diamicton: matrix supported; massive; silty sand matrix; 30% clasts, small to medium pebbles, rare cobbles, subangular; pebble fabric 891508; lower contact is gradational.
	Bedrock:	Conglomerate-breccia; red-brown-purple colour; more than 60% clasts, small to large pebbles, mostly small to medium, angular to subrounded, mostly subangular; massive to chaotic appearance; one bed of medium to coarse sandstone 10 centimetres thick, well stratified with beds ~1 centimetre thick, truncated tops and lens-like form; clast lithologies include sandstone, siltstone, igneous rock types, quartzites and ironstones; matrix of medium sands; bedrock surface is smooth and has grooves that trend at 170-350°, they are 1-2 centimetres deep, and 5-8 centimetres amplitude between undulations, possible flutings; 1-2 metres exposed.

Section 8915D

Location: This section is located on the same highwall as Section 8915A but approximately 110 metres farther west (Figure 24).

Unit	Height above base (m)	Description:
2	6.5 - 7.5	Diamicton: matrix supported; grey; loosely consolidated, possibly colluvial; upper contact truncated by mining; lower contact is sharp and trough shaped.
1	2.5 - 6.5	Diamicton: matrix supported; matrix of silty clay; brown; 10-20% clasts, pebbles and rare cobbles, commonly striated; horizontal partings in the lowest metre, slickensides along partings (010-190°); some of the partings dip to the north, some close to horizontal; partings are often polished, in places have a discontinuous silty clay layer 0.1-1 centimetre thick; 2 metres of diamicton grades into 2 metres moderately to poorly sorted coarse sands with oxidized, pebbly gravel lenses and some discontinuous, well-sorted fine and medium sand lenses; lower contact is sharp, planar and horizontal to gently dipping to the north .
	0.5 - 2.5	Bedrock: shale, silts and clays, black and very organic rich, fine-grained carbonaceous; fractured, slickensided and brecciated in places; has some coarser, more blocky beds closer to the top; minor strongly brecciated quartz veins; bedding and foliation are nearly vertical in places; upper metre is highly disrupted and more oxidized; lower contact is sharp and changes from a vertical slickensided plane to a plane dipping at 45° to the south (190°).
	0 - 0.5	Bedrock: light and dark grey, fine-grained volcanic breccia and sediments; possibly sheared soft, soapy, graphitic and strongly oxidized; abundant cubic pyrite, rarely disseminated, some in quartz veins; possibly some bornite; lower contact is covered.

Section 8915F (Dead Cottonwood Section)

Location: Section is in an active mine pit about 50 metres northwest of Mary Creek and 100 metres west of the Toop residence (Figure 24).

Unit	Height above base (m)	Description:
13	7.45 - 8.2	Large-pebble gravel: poorly sorted; crude subhorizontal strata; medium-pebble beds alternating with large-pebble beds and rare cobbles; matrix of medium and coarse sand with some fine sand; some better sorted openwork patches; unit is oxidized reddish brown, openwork beds more oxidized; bedding is discontinuous and irregular; laterally this unit has sand beds, fine to coarse sand beds up to 20 centimetres thick; some moderately sorted, almost openwork, small-pebble beds up to 20 centimetres thick; poorly consolidated; soil is developed on this unit, an Ae and a thick Bf; pebble

		lithologies 16% mafic igneous, 16% quartzite,14% vein quartz, 10% schist, 8% quartz gneiss, 8% chert, 8% phyllite, 8% siltstone, 6% diorite, 2% granite, 2% shale, 2% sandstone; lower contact is sharp and scoured.
12	6.7 - 7.45	Diamicton: matrix supported; silty sand matrix; clast content varies from 5-20%, small to large pebbles with cobbles, mostly subangular to subrounded; contains some discontinuous, well-sorted fine sand lenses 1-2 centimetres thick; the diamicton has some mottling along fractures and joints; sorting is better closer to the top of the unit; unit is loosely consolidated; lower contact is gradational.
11	6.2 - 6.7	Diamicton: matrix supported; sand-silt-clay matrix; unit thickens to 1 metre to the south; very compact; reacts weakly to hydrochloric acid; ~10% clasts, subangular to subrounded; some subhorizontal partings, 3-4 centimetres apart, breaks into large blocks along partings; poorly developed slickensides occasionally visible, 060-240°; partings are somewhat trough shaped, bases appear like platelets stacked on each other, are slightly greyer than the surrounding sediment; clasts are commonly oblong or bullet shaped, flat lying, parallel to partings; pebbles are mostly quartzites or igneous rocks; pebble sample 8921; lower contact is horizontal, diffuse over 2 centimetres; contact is sometimes marked by the presence of a slickensided (145°) well-laminated silt and sand bed.
10	3.9 - 6.2	Sand, silt and clay: to the north this unit is silt and clay rich, to the south sand is more dominant; horizontal strata; silt and clay laminations 0.5 centimetre thick, bounded by fine sand lenses up to 2 centimetres thick; sand lenses have gentle trough shapes, some lenses have pillow (load) structures; subhorizontal partings common; over consolidated; steeply dipping (50°) slickensided surfaces dip southeast (150°); some massive sand beds; basal metre has well-developed horizontal beds, up to 5 centimetres thick, that are commonly deformed; manganese staining quite common; some pebbly lenses near the base, less than 10 centimetres thick and less than 1 metre wide; sand sample 8922 taken at 4.9 metres, pebble sample 8923 taken at 5.2 metres; lower contact is sharp and planar.
9	3.7 - 3.9	Medium-pebble gravel: clasts up to large pebbles, subangular to rounded; poorly sorted; matrix of fine to coarse sands with granules; crudely stratified with some normal grading; unit fines upward into a small-pebble gravel at the top; lower contact is sharp and planar.
8	3.4 - 3.7	Fine sand: some coarse granular sand beds, up to 2 centimetres thick; unit fines upward overall; wavy, parallel laminations; dip south (200°) at 2°; lower contact is clear and planar, conformable.
7	2.9 - 3.4	Pebble-cobble gravel: clast supported; occasional small boulders; matrix of coarse sand to small pebbles, very little fine sand; poorly to moderately sorted; moderate imbrication, suggests flow to the south; clasts are subrounded to well rounded, some subangular; lower contact dips south (200°) at 6°, planar and clear.
6	2.3 - 2.9	Large-pebble gravel with cobbles which occur in clusters near the base of the unit: poorly sorted; matrix of fine sand to medium pebbles, little silt; small, well-sorted, trough-shaped, fine to medium sand lenses up to 20 centimetres thick and 50 centimetres wide; clasts are angular to rounded, moderate imbrication; lower contact is sharp and scoured, scours are 50 centimetres deep and 2 metres wide, contact dips at 5-20° southwest (250°).
5	1.9 - 2.3	Fine sand and silt: no obvious stratification; numerous slickensided fracture planes, dipping more than 45° to the east; 10% scattered pebbles; unit coarsens upward; locally oxidized; lower contact is sharp and planar, dips southwest (250°) at 2-5°.
4	1.4 - 1.9	Small to medium-pebble gravel: moderately well sorted; matrix of fine to coarse sand; moderate imbrication suggests flow to the southwest; clasts are angular to rounded; crude stratification; iron oxide staining and cementing make this unit hard; pebble lithology (sample 8924) 32% siltstone, 16% quartzite, 12% vein quartz, 12% mudstone, 12% gneiss, 8% schist, 4% sandstone, 4% diorite; lower contact is sharp and slightly scoured, dips 2-5° southwest, unit thickens to the south and scours get progressively deeper.
3	1.25 - 1.4	Small to medium-pebble gravel: crude stratification; moderately well sorted; matrix of fine to coarse sand; clasts are subangular to subrounded, mostly discs and blades, commonly flat lying, may be imbricated; manganese stained and strongly cemented, very hard to break; lower contact is sharp, planar and horizontal.
2	1.1 - 125	Fine sand and silt: horizontally laminated with some trough crosslaminations; lensoid unit which pinches out to the north and south, unit is about 5 metres long; sand sample 8925; lower contact is sharp and trough shaped.
1	0 - 1.1	Medium to large-pebble gravel, some cobbles: moderate imbrication; well stratified; small sandy lenses, thin and discontinuous; very strongly manganese stained and cemented, dark black colour; pebble lithology (sample 8926) 32% vein quartz, 16% quartzite, 16% siltstone, 12% quartz gneiss, 12% mafic igneous, 8% sandstone, 4% ironstone; lower contact is covered.

Section 8915G (Upper House Section)

Location: This section is located just east of the Toop residence on the northeast wall of the main mining site (Figure 24).

Unit	Height above base (m)	Description:
12	9.5 - 10.5	Pebbly sand: poorly exposed; probably colluvium.

11	7.5 - 9.5	Small to medium-pebble gravel: poorly sorted.
10	5.0 - 7.5	Small to medium-pebble gravel: clasts are mostly well rounded; medium sand matrix, moderately well sorted.
9	2.9 - 5.0	Small to medium-pebble gravel: horizontally stratified; clasts are mostly well rounded, with a medium sand matrix, moderately well sorted; beds are 5-10 centimetres thick; some trough shaped, well-sorted, small and medium-pebble gravel lenses.
8	2.8 - 2.9	Fine to medium sand with discontinuous beds of coarse sand and small pebbles: horizontal stratification.
7	2.6 - 2.8	Small to medium-pebble gravel: clasts are mostly well rounded, with a medium sand matrix, moderately well sorted.
6	2.5 - 2.6	Fine to medium sand with discontinuous beds of coarse sand and small pebbles: horizontal stratification.
5	2.25 - 2.5	Small to medium-pebble gravel: clasts are mostly well rounded; medium sand matrix, moderately well sorted, few large pebbles, the unit is trough shaped, thickening to the south; lower contact is sharp and erosional.
4	2.0 - 2.25	Silt and clay: horizontally laminated; some wavy laminations with minor fine sandy laminae and with two diamicton beds in the upper part that are 1-3 centimetres thick having a silty sand matrix and clasts up to medium pebbles in size. The lower contact is sharp and planar and dips to the south (160°) at 7°.
3	1.3 - 2.0	Sand and gravel: gravel beds are moderately to poorly sorted, 2-20 centimetres thick and are sandy small-pebble gravel to sandy medium to large-pebble gravel; clasts are subangular to rounded, mostly quartzites and vein quartz (not local), some diorite. Sand beds are well-sorted fine sand with horizontal laminations; some poorly sorted coarse sand and pebbly sand beds that are 10 centimetres thick. Unit is trough shaped and the lower contact is sharp and scoured into the underlying unit.
2	0 - 1.3	Diamicton: matrix supported; silt, sand and clay matrix; massive; poorly exposed; grey; some striated clasts; lower contact is covered. To the north the lower contact of this unit is sharp and planar and a bedrock low underneath the unit is filled with a brown oxidized diamicton with a silty sand matrix and numerous clasts of angular bedrock as well as some striated clasts. This unit thickens to the north and is very crudely stratified; strata dip north. (This unit is possibly a leeside till).
1		Bedrock: siltstone; thickly bedded, 5-10 centimetres; fractured, in places entirely brecciated; some brecciated quartz; poorly exposed at base of the section; siltstone and quartz are sheared.

Note: Units 3-12 all thicken toward the valley centre (southwest) probably where bedrock drops. A small section below the Toop residence shows a similar stratified gravel sequence overlying bedrock.

Section 9015H

Location: This section is in a test pit dug by Farrow Resources about 25 metres south of Mary Creek. The pit is located on the south side of the creek opposite and downstream from the Toop residence (Figure 24).

Unit	Height above base (m)	Description:
9	6.0 - 7.0	Interbedded silty diamicton, silt and clay: bed contacts are diffuse and irregular, probably colluvial material.
8	4.1 - 6.0	Fine sand with silt and scattered pebbles: possibly laminated but not obvious; poorly exposed.
7	3.8 - 4.1	Sandy large-pebble gravel: clast supported; matrix filled; abundant vein quartz clasts; lower contact is diffuse and poorly exposed.
6	3.4 - 3.8	Fine sand: weak horizontal bedding; very well sorted, micaceous, greyish; horizontal lower contact.
5	2.5 - 3.4	Boulder and large-cobble gravel: grading upward into a medium-pebble gravel; disorganized or chaotic, possibly some imbricated clast clusters at the base; mostly a fine to coarse sand matrix; small lenses or pockets of openwork pebble gravel occur around large boulders; clasts are rounded to well rounded, mainly distal lithologies, pebble lithologies: quartzites 36%, fine-grained diorite 4%, quartz gneiss 8%, metasiltstone 4%, shale (rounded) 16%, metavolcanic 4%, muscovite schist 8%, medium to fine-grained extrusive 4%, vein quartz 16%; manganese oxides in the bottom half and iron oxides in the top half; lower contact is sharp and weakly scoured to planar, mainly erosional.
4	2.25 - 2.5	Fine sand with beds of medium to coarse sand: horizontally laminated; fine sand is well sorted; beds are 1-2 centimetres thick; unit thins slightly to the northwest; lower contact is sharp and planar; iron and manganese staining along bed contacts but also some crosscutting relationships.
3	2.0 - 2.25	Small to medium-pebble gravel: massive to crudely imbricated (indicating paleoflow to the northwest); possible very crude horizontal bedding; poorly to moderately sorted; distinct from underlying units because it has less matrix and is a different colour; local bedrock clasts angular to subangular; distal clasts subrounded to rounded; matrix is fine sands and coarser, possibly some silt; pebble lithologies, shales (mostly angular, rarely rounded) 48%, fine-grained metavolcanics 16% (12% brown, 4% black), vein quartz 12%, gneiss 8%, quartzite 8%, schist 4%, hornblende andesite (?) 4%; unit thins to the northwest; lower contact is erosional, undulatory and locally dips 2-3° toward 310°.

2	0 - 2.0	Interbedded diamicton and very fine sand lenses: sand lenses are 10-20 centimetres thick and 5 metres wide (or more), trough shaped and horizontally laminated; diamicton: matrix supported; clasts are mainly small to medium pebbles (angular or subangular, some subrounded, most are local shale clasts, some vein quartz); diamicton matrix is a sandy silt; beds are 10 to 100 centimetres thick and also form trough-shaped lenses; lowest diamicton beds are poorly sorted or unsorted while upper beds are poorly sorted and almost gravelly; the lowest diamicton bed has some large-pebble sized angular clasts at the base; clasts in upper diamictons are more rounded and distal than at the base.
1		Bedrock: shale; dips at 35° towards 075°; thinly bedded; breaks into blocks about 5-10 centimetres thick, black, oxidized on fractures; bedrock-gravel contact dips southeast (135°); bedrock also drops to the northwest under the creek towards section 8915F where a borehole reached bedrock at about 10 metres with rich gold-bearing gravels near the base; up to 2 metres of bedrock is exposed.

Section 9015I

Location: This section is located in a small, probably postglacial terrace on the north side of Mary Creek just downstream from the Toop residence (Figure 24).

Unit	Height above base (m)	Description:
3	2.2 - 3.4	Crudely stratified sands with minor pebble horizons: lower contact gradational.
2	0.6 - 2.2	Large-pebble to cobble gravels: horizontally bedded; crude imbrication with paleoflow towards the northwest; minor openwork pockets and lenses; poorly to moderately sorted; weakly oxidized; openwork beds appear to be manganese stained; unit consists of three beds; a prominent bed in the middle consists of sand lenses and openwork gravels; lower contact clear and horizontal.
1	0 - 0.6	Small to medium-pebble gravels and medium to coarse sands: horizontally bedded; sand beds are 1-5 centimetres thick, gravels are 5-20 centimetres thick; lower contact covered.

SITE 16 - MONTGOMERY CREEK

Owner/operator: Bob Marrs
NTS: 93 H/4 Wells
Latitude & Longitude:53°06'N, 121°44'W
UTM: 5885600 m N, 584300 m E
Year of property visit: 1990

Site Description:

This section was measured along a cut-bank exposure in a bench above the Willow River just east of the mouth of Montgomery Creek. The section base is at river level. The top of the section is a flat terrace. Two small old hydraulic pits have been worked along Montgomery Creek.

Section 9016

Location: This section was described on a low terrace of the Willow River at the base of an old hydraulic pit on Montgomery Creek.

Unit	Height above base (m)	Description:
25	25.0 - 27.0	Pebbly sand: poorly exposed.
24	23.0 - 25.0	Poorly exposed but similar to 21.0 - 23.0.
23	21.0 - 23.0	Interbedded cobble gravel and large-pebble gravel: mostly openwork; crude horizontal bedding; matrix is fine sand and coarser; minor matrix-filled beds; beds are 25 centimetres thick; clasts are subrounded to rounded and of mixed lithologies; pebble lithologies, 24% pyritiferous phyllite, 20% vein quartz, 16% igneous, 12% gneiss, 12% quartzite, 8% schist, 4% sandstone, 4% quartz gneiss.
22	20.0 - 21.0	Large-pebble gravel: chaotic; mainly openwork; gravel ranges from small pebble to large cobble; clasts are subangular to subrounded; gravels are laterally interbedded with very fine sands that contain scattered angular cobbles in a matrix-supported fabric; deformed bedding; 50% angular cobbles; mostly vein quartz and siliceous phyllites; some moderately sorted openwork zones of small to medium pebbles.
21	18.1 - 20.0	Large-pebble to small-cobble gravel: poorly exposed; poorly sorted; matrix filled; fine sand and coarser; minor horizontally laminated fine sand beds.
20	17.6 - 18.1	Fine sands with some medium to coarse sand beds: horizontally laminated; beds are 1-2 centimetres thick.
19	17.1 - 17.6	Small-pebble gravel: matrix-filled gravel interbedded with horizontally laminated fine sands; beds 5-10 centimetres thick.

18	16.7 - 17.1	Large-cobble (and boulder) gravel: poorly sorted; clasts are subangular to angular; matrix filled with fine sand and coarser; local phyllite clasts common; angular boulders up to 50 centimetres diameter.
17	16.2 - 16.7	Interbedded medium to coarse sand, fine sand and pebbly sand: horizontally bedded; coarser beds are oxidized (iron); beds 2-10 centimetres thick; gravelly beds are poorly sorted, matrix filled and have abundant angular clasts of vein quartz and local phyllite.
16	15.2 - 16.2	Very fine and fine sands: horizontally bedded or laminated; unoxidized, greyish colour.
15	14.95 - 15.2	Interbedded fine to medium sands and small-pebble gravel: horizontally bedded; beds 2-5 centimetres thick; oxidized.
14	12.95-14.95	Medium to large-pebble gravel: beds are horizontal and 5-25 centimetres thick; moderately imbricated; mostly matrix filled, partially openwork, matrix is a coarse sand with some medium sand; openwork beds are more oxidized (reddish colour - iron oxides).
13	12.85-12.95	Fine and very fine sand: well bedded or laminated; large-scale trough crossbedding in the upper 2-3 metres; lens shaped unit about 5 metres wide; very well sorted; lenses of sand are common, trough shaped and occur throughout the unit.
12	12.55-12.85	Medium-pebble gravel: horizontally bedded; good imbrication; openwork; manganese stained (moderately); manganese staining gets stronger (very black) towards the top; strong manganese stained areas are cemented; some small-pebble beds; beds are about 10 centimetres thick; clasts are dominantly quartz-vein material; subrounded to rounded; some strongly weathered clasts, probably sandstone and igneous. Upper part of unit is a lens with strong iron oxide staining. Pebble lithology sample 9026.
11	11.8-12.55	Medium to large-pebble gravel: matrix filled; coarse sand matrix.
10	11.7 - 11.8	Large-pebble gravel: openwork.
9	11.2 - 11.7	Medium-pebble gravel: matrix very coarse sand; imbricated, northerly paleoflow, parallel to the Willow River. Pebble lithology sample 9025.
8	10.2 - 11.2	Sandy small to medium-pebble gravel: matrix filled.
7	10.1 - 10.2	Small-pebble gravel: manganese oxides; openwork.
6	9.8 - 10.1	Granular to medium sand: poorly sorted; normally graded.
5	9.2 - 9.8	Medium to large-pebble gravel: oxidized patches; matrix filled.
4	8.9 - 9.2	Small to medium-pebble gravel: unoxidized; matrix filled.
3	8.7 - 8.9	Medium to coarse sand: moderately sorted; lens-shaped unit.
2	8.0 - 8.7	Small to large-pebble gravel: horizontally bedded; matrix filled; matrix of medium sand and coarser; iron oxide staining from 8.0-8.3 metres, manganese and iron staining from 8.3-8.5 metres and no oxidation from 8.5-8.7 metres. Pebble lithology sample 9024 taken at 8.3-8.5 metres.
1	0 - 8.0	Pebble gravel: mostly covered or poorly exposed; horizontally bedded, at least in the upper 2 metres; beds 10-20 centimetres thick, minor openwork, mostly matrix filled, small zones of iron staining; clasts are subrounded, small to medium pebbles; some layers of cemented gravel beds 30 centimetres thick at about 2-3 metres above river level; cemented with iron oxides; some angular (to subangular-subrounded), black, oxidized argillite clasts containing pyrite and small amounts of gold; lower contact covered.

SITE 17 - UPPER GROUSE CREEK

Old hydraulic pit
NTS: 93H/3 Spectacle Lakes
Latitude & Longitude:53°01'N, 121°27'W
UTM: 5876800 m N, 603200 m E
Year of property visit: 1990

Site Description:

The valley of upper Grouse Creek is deep and narrow with bedrock exposures along most of its length, although thick sequences of sediment are locally exposed such as at the section described below. Tailings piles and evidence of old workings are abundant but no signs of recent mining activity were observed along this part of the creek. Productive buried channels (*e.g.*, the Heron channel) in this region made it one of the principal mining areas in the Cariboo in the 1860s.

Section 9017

Location: This section is exposed on the southeast side of the upper Grouse Creek valley just downstream from Shy Robin Gulch.

Unit	Height above base (m)	Description:
20	65.0 - 90.0	Sands capped by 1-5 metres of large-pebble gravel: sands well sorted; gravels openwork to matrix filled with coarse sand; clasts subrounded to well rounded; poorly exposed; some slumping; unit is at least 15-20 metres thick; gravels have an erosional lower contact.
19	64.0 - 65.0	Fine sands: horizontally bedded.
18	63.0 - 64.0	Fine sands: horizontally bedded; beds are 2-10 centimetres thick; normally graded.
17	62.0 - 63.0	Fine sands: horizontally bedded; beds are about 25 centimetres thick; minor interbeds of very fine sands (almost silty); some internal laminae in the fine sands; beds are normally graded, especially in very fine sands.
16	60.0 - 62.0	Fine sands: trough crossbedded; troughs dip at 9° towards 330°; poorly exposed; well sorted; unit is capped by 20 centimetres of horizontally bedded very fine sand; very fine sand beds have gradational lower contacts and sharp upper contacts with overlying coarser beds; conformable lower contact, probably planar.
15	58.0 - 60.0	Fine sands: horizontally bedded; beds are 1-20 centimetres thick; well sorted; minor coarse sand beds and some pebbly coarser sand beds; poorly exposed.
14	56.0 - 58.0	Fine sands: large-scale trough crossbedding; beds are 2-20 centimetres thick; very well sorted; individual beds exhibit parallel laminae; lower contact is trough shaped, troughs are ~2 metres deep over a distance of 20 metres.
13	53.8 - 56.0	Bouldery gravel: matrix filled; clast supported; matrix is coarse sand; poorly sorted; some small lenses of moderately to well-sorted pebble gravel which are approximately 70 centimetres thick.
12	53.5 - 53.8	Coarse sand to small-pebble gravel: crude horizontal bedding; matrix filled with medium sands; one large-pebble to small-cobble bed; lower contact gradational.
11	53.0 - 53.5	Large-pebble to small-cobble gravel: similar to Unit 9 except some openwork lenses and pockets which are oxidized and strongly cemented; beds have apparent dip of 15° to the west (270°); lower contact is erosional and scoured, scours are 25 centimetres deep by several metres wide.
10	52.8 - 53.0	Medium to coarse sand: horizontally laminated; moderately well sorted; gradational lower contact; unit is lens shaped about 5 metres wide.
9	52.3 - 52.8	Large-pebble to small-cobble gravel: matrix filled; medium sand and coarser; clasts are subrounded to subangular; lower contact is sharp and planar, dips to the west at 5-10°.
8	51.9 - 52.3	Medium-pebble gravel fining upward to small-pebble gravel: planar crossbedding dipping to the west similar to Unit 7; beds 3-7 centimetres thick; some openwork, but mostly matrix filled; matrix of medium to coarse sand; lower contact gradational.
7	51.5 - 51.9	Large-pebble to boulder gravel (average small cobble): matrix filled, matrix of medium to coarse sand with minor granules; bimodal; clasts subrounded to angular; boulders up to 75 centimetres diameter; lower contact dips (apparently) 7° to the west (dip direction 260°).
6	50.6 - 51.5	Large-pebble to cobble gravel grading upward into a medium to large-pebble gravel: crude large-scale trough crossbedding; clast supported; some openwork beds and some matrix filled; matrix is coarse sand and granules; clasts are subangular to rounded.
5	50.3 - 50.6	Granular to small-pebble gravel: clast supported; mostly openwork; some medium-large pebbles at base (in a granular to small-pebble matrix), unit fines upward and dips to the west (280°) at 21°; oxidized and moderately cemented, strongly cemented at base; oxidation is laterally discontinuous; clasts are subrounded to subangular; lower contact is sharp and planar (conformable).
4	50.0 - 50.3	Small to large-pebble gravel: minor cobbles; crude trough crossbedding; clast supported; matrix of coarse sand; poor to moderate sorting; clasts are subrounded to rounded; lower contact covered.
3	40.0 - 50.0	Coarse sandy pebble gravel: poorly exposed.
2	20.0 - 40.0	Coarse boulder to cobble gravels: poorly exposed.
1	0 - 20.0	Covered.

SITE 18 - LITTLE SWIFT RIVER

Owner/operator: Overleigh Resources Ltd./Jake Peters
NTS: 93A/13 Swift River
Latitude & Longitude: 52°55'N, 121°46'W
UTM: 5863500 m N, 583000 m E
Year of property visit: 1990

Site Description:

This site is located along the Little Swift River about 2 kilometres north of its confluence with the Swift River. Gold-bearing gravels underlying a thick overburden sequence are exposed on the south side of the creek (Section 9018B). Active mining is occurring on low-terrace gravels, such as those exposed at Section 9018A .

Section 9018A

Location: This section is in a test pit on a low terrace on the north side of the Little Swift River about 200 metres upstream from the forestry road bridge.

Unit	Height above base (m)	Description:
4	4.2 - 5.0	Coarse granular sand with some scattered pebbles and cobbles at the base: planar crossbedded; lower contact sharp and planar to slightly scoured.
3	1.9 - 4.2	Cobble gravel with a few boulders grading upward into pebble gravel and sands; beds dip north; clasts dip parallel to the slope; cobble bed at base is 60 centimetres thick, chaotic and has a sandy granular matrix; small to large-pebble gravels are openwork and beds are 4-25 centimetres thick and fine upward (large-pebble, openwork, oxidized gravel fining upward to matrix-filled, small-pebble gravels); medium to coarse sands in the upper part of the unit are well bedded and form a trough-shaped unit; clasts are subrounded to well rounded; some igneous, shale, quartzite clasts; paleoflow to the northeast; lower contact erosional.
2	0.55 - 1.9	Interbedded gravelly sand, sand and gravel: crude horizontal stratification; gravelly sand beds are 10-30 centimetres thick and poorly to moderately sorted, some beds are silty (almost diamicton); clasts mostly up to large pebble size; sandy layers are moderately to well sorted; fine and coarse sand beds; weak laminations; sands infill around large clasts; pebbly beds and sandy beds are up to 10 centimetres thick or thicker in lenses; pebbly beds are mostly granular to small pebbles and lensoid; the upper 50 centimetres of the unit has occasional small boulders and small (20 centimetres by 1 metre) lenses of horizontally bedded fine sands with pebbles and small granule beds; bed contacts are diffuse; lower contact is sharp and horizontal.
1	0 - 0.55	Sandy medium to large-pebble gravel: weak imbrication; horizontal bedding; paleoflow to the east, parallel to the modern creek; abundant matrix (medium sand to small pebble); clasts subrounded to rounded; clasts up to small boulders along the lower contact, mostly large pebbles; lower contact is sharp, planar and marked by a horizontal to undulatory, manganese oxide stained layer 1-3 centimetres thick about 0-20 centimetres above bedrock; unit is capped by a similar manganese and iron-stained layer. This is the main gold-bearing unit with mostly fine gold but nuggets up to 1 centimetre diameter have been recovered. Pebble lithology sample 9007.
	Bedrock:	Metasediment: schistose; quartz eyes; vertically jointed; breaks into blocks; water-smoothed on upper surface; about 50 centimetres exposed; bedrock sample 90-06.

Section 9018B

Location: The measured section is on the south side of the Little Swift River, directly upstream from the bedrock canyon above Section 9018A. It is an exposure along the valley side on a low terrace 100 metres from, and 10-15 metres above, the level of the river. The topography on the top of the section is also terraced. The gravel units at the base of the section were described along the limb of a broad trough-shaped channel-form unit. Paleoflow direction towards 220° with axis of the trough oriented 220-280°.

Unit	Height above base (m)	Description:
9	24.0 - 25.0	Silts and fine sands: horizontally laminated with minor ripple bedding in sands; strata thicken upwards so that the upper 20 centimetres are thickly bedded.
	20.0 - 24.0	Covered (probably diamicton).
8	12.15 -20.0	Silty sand diamicton: massive; matrix supported; very compact, dense and hard; unit is poorly exposed; noncalcareous; clasts are up to boulder sized, mostly medium to large pebbles; about 20% clasts; clasts are subangular to subrounded; striated clasts are frequently present; lower contact is diffuse. Pebble lithology (sample 9011) from the lower 20 centimetres of the diamicton, gneiss 28%, schist 28%, quartzite 16%, greenstone (fine-grained metavolcanics) 16%, vein quartz 8%, black siltstone 4%. There are also some coarse-grained pyroxenite ultramafics and an olivine dunite clast.
7	7.65 -12.15	Small-pebble to boulder gravels: horizontally bedded; poorly sorted, especially the coarser layers with a fine sand and coarser matrix; bouldery layers have boulders floating in a silt to gravel matrix; pebbly layers are moderately sorted at best, with crude horizontal bedding and a sandy matrix; numerous horizontally bedded, trough-shaped sand lenses up to 50 centimetres thick and about 3 metres wide; unit fines upward from a small pebbly granular gravel to medium sands at the top; top contact is eroded by coarse gravels; lots of small pebbly sand interbeds 5-10 centimetres thick; lower contact is conformable onto coarser layers below; the unit changes laterally, in some places it is almost all cobbles and lacking stratification.
6	3.65 - 7.65	Large-pebble to large-cobble gravel: massive to crudely stratified; dominant sedimentary structure is gentle trough-shaped beds of openwork medium-pebble to cobble gravel; poorly to moderately sorted; chaotic to crudely imbricated fabric; matrix varies from a poorly sorted silt to granular sand; minor silt lenses, 1 centimetre by 10 centimetres; clasts are subangular to rounded, mostly subrounded and of varied shapes; openwork beds are weakly manganese stained. Pebble lithologies,

		gneiss 28%, muscovite schist 24%, greenstone 12%, vein quartz 8%, quartzite 24%, metasediment 4%. Lithology of cobbles is dominantly greenstone (fine-grained intrusives, extrusives or metasediments) or gneiss. The lower contact of this unit is mostly planar, with some scouring, scours are 1 metre deep and up to 5 metres across.
5	3.45 - 3.65	Granular sand grading upward into fine sands and silts: fine sands and silts are horizontally laminated; lower contact is sharp and horizontal and marks the top of the oxidized gravels. Laterally to the west (250°) about 25 metres, the oxidized gravels have numerous very well sorted fine sand lenses, up to 50 centimetres thick and 1 metre wide, that have been scoured into episodically by medium to coarse pebble gravels.
4	2.85 - 3.45	Medium to large-pebble gravel: massive or very crude horizontal stratification; minor silt in matrix; similar to Unit 2 but stratification weaker and sorting poorer than in Unit 2. Pebble fabric 901816.
3	2.65 - 2.85	Sandy large-pebble to cobble gravel: crudely imbricated; large-scale trough crossbedding; beds dip up to 6° towards 320°; moderately to poorly sorted; unit forms a trough-shaped lens; may be reversely graded in the lower part; unit is capped by a horizontally laminated fine sand lens that is about 100 centimetres wide and 5 centimetres thick and drapes around some of the cobbles in the upper part of the unit; lower contact is gently scoured.
2	0.55 - 2.65	Medium-pebble to cobble gravel: crude horizontal stratification; imbricated; cobble-gravel bed from 1.55-1.85 metres continuous for over 5 metres; a large pebble bed from 2.15-2.65 metres; imbrication better developed in pebbly beds; pebbly beds mainly openwork with iron and manganese staining; rare, flat-lying, medium sand lenses, 2 centimetres thick by 2 metres wide; cobble beds moderately sorted with a coarse sand to pebble matrix; clasts are mostly subrounded to well rounded, the coarser clasts (large pebbles and cobbles) are sometimes subangular; numerous tabular clasts; pebble lithologies, biotite schist 8%, quartzite 40%, diorite (fine-grained intrusive) 8%, metasediment (fine to medium grained) 12%, vein quartz 12%, gneiss (quartz)16%, phyllite 4%. Pebble fabric 901815.
1	0 - 0.55	Granular to small-pebble gravel: horizontally bedded; beds are 2-10 centimetres thick; from 0.32-0.34 metres and 0.42-0.48 metres there are some fining-upwards, fine to medium sand interbeds with ripple bedding (trough crossbeds at the base that are draped at the top with silt ripples); paleoflow measurements on ripple beds (dip 16° towards 240°) indicate paleoflow was to the west-southwest; generalized flow appears to be to the west; gravels are subangular to rounded, moderately to well sorted, fairly clean; iron oxide staining on bedding contacts; lower contact covered.

SITE 19 - MOREHEAD CREEK

Owner/operator: Frank Ambler
NTS: 93A/12 Hydraulic
Latitude & Longitude: 52°39'N, 121°48'W
UTM: 5833000 m N, 581500 m E
Year of property visit: 1989

Site Description:

This property is located about 1.5 kilometres south of the Quesnel River and 6 kilometres northwest of the Bullion mine. The measured section is a natural exposure on the southwest side of Morehead Creek. Approximately 30 to 50 metres of covered material separates the base of the exposure from bedrock exposed in the creek. The deposits currently being mined are about 30 metres below and 250 metres downstream from the measured section.

Section 8919 (Morehead Channel Section)

Location: The measured section is located on the southwest side of Morehead Creek, approximately 2 kilometres upstream from its confluence with the Quesnel River.

Unit	Height above base (m)	Description:
10	35.0 - 37.0	Silts and clays: horizontally laminated.
9	34.0 - 35.0	Fine sands: horizontally bedded.
8	33.0 - 34.0	Silts and clays with sands: horizontally laminated.
7	31.0 - 33.0	Fine sands: horizontally bedded.
6	26.0 - 31.0	Medium to large-pebble gravel, rare cobbles: clast supported; poorly sorted; matrix of coarse to fine sand; crude horizontal to trough crossbedding; minor openwork layers; interbedded with sands to the west; occasional lenses of horizontally bedded sands; lower contact is scoured, scours up to 2 metres deep.
5	24.0 - 26.0	Medium sands: well sorted; large-scale trough crossbedding, foresets have pebbles on them; laterally pebbly gravels interfinger with the sands; lower contact is sharp and trough shaped.

4	20.0 - 24.0	Silts and fine sands with some clays grading upward into medium and coarse sands; horizontally laminated to horizontally bedded; beds are 1-3 centimetres thick; unit thickens to the west to about 10 metres, silty sands remain about 2 metres thick, the sandier beds thicken to 8 metres; lower contact is conformable.
3	14.0 - 20.0	Medium to large pebbles: poorly sorted; beds are commonly deformed; in the lower part of unit beds dip at 40° to vertical, these are openwork, medium to large-pebble beds with some sands and pebbly sand beds; upper part of unit has less distinct bedding; lower contact is clear and unconformable.
2	10.0 - 14.0	Medium to large-pebble gravel: moderately to well-sorted; beds 10-40 centimetres thick; some openwork large-pebble to cobble beds, up to 50 centimetres thick and some small and medium-pebble openwork beds up to 25 centimetres thick; normal faulting common, displacements up to 1 metre and dips of 80° to the west; lower contact defined by an openwork, large-pebble to cobble bed in a scoured trough, scour is 2 metres deep and 10 metres wide.
1	0 - 10.0	Medium to large-pebble gravel: moderately to well sorted; horizontal to trough bedding; gravels are mixed granule to medium-pebble beds, 10-40 centimetres thick, large-pebble to cobble beds, 20-40 centimetres thick with well-sorted, laminated fine to coarse sand matrix; well-sorted sand beds, horizontally bedded; unit is trough shaped, trough oriented north-south; numerous normal faults, dipping 80° to the west with displacements of 50 centimetres to 2 metres; to the west this unit is equivalent to a large trough-shaped lens of fine to medium sands interbedded with poorly sorted pebble beds overlying a poorly sorted pebble-gravel unit; lower contact is covered.

SITE 20 - BULLION MINE

Owner/operator: Vardex
NTS: 93 A/12 Hydraulic
Latitude & Longitude: 52°37′N, 121°38′W
UTM: 5831500 m N, 592200 m E
Year of property visit: 1989

Site Description:

The Bullion mine is located about 5 kilometres west of Likely in an old channel of the Quesnel River. A measured section at the site was described by Clague *et al.* (1990). Summary descriptions of the section are given earlier in this report. Figure 22 is a composite stratigraphic column illustrating the sequence of deposits exposed.

SITE 21 - SPANISH MOUNTAIN

Owner/operator: Peter and Virginia McKeown
NTS: 93A/11 Spanish Lake
Latitude & Longitude: 52°35′N ,121°28′W
UTM: 5827200 m N, 604000 m E
Year of property visit: 1989,1990

Site Description:

This property is located on the northwest side of Spanish Mountain about 8 kilometres east of Likely. The most complete descriptions of the auriferous deposits are given below under Sections 8921A and B. A detailed description of the overburden was obtained at Section 8921D (Unit 2). The mining history at this site is briefly described in Chapter 5.

Section 8921A (Fording Coal Pit Section)

Location: This section is located near the south end of the mine on the south wall of an open pit worked by Fording Coal Ltd.

Unit	Height above base (m)	Description:
9	4.95 - 5.95	Large-pebble to cobble gravel (small pebbles to boulders up to 1 metre diameter): unit overall coarsens upward with boulders mainly at the base; gravels chaotic; matrix fine to medium sand (minor silt, coarse sand); varies from matrix to clast supported; clasts are angular to well rounded, mostly subrounded; steeply dipping fractures (80° to the west), less than 1 centimetre thick, infilled with silty clay and in places branched, but with no obvious displacement; lower contact is sharp to indistinct.
8	3.95 - 4.95	Fine to coarse sand with scattered pebbles and granular to medium pebbly sand: rare cobbles; well to moderately sorted; strongly contorted laminae of fine sand and silt at the base and top; lower contact irregular and gradational.

7	3.75 - 3.95	Fine to medium sand (>50% fine to medium sand): massive; poorly sorted; some large pebbles and rare cobbles; grades laterally into sandy diamicton with clasts up to 75 centimetres (boulders), matrix supported with more fine sand and some silt; lower contact gradational.
6	3.25 - 3.75	Fine sand: thin irregular to wavy bedding (deformed); beds 10-20 centimetres thick; well to very well sorted; some coarse, moderately sorted granular sands, beds 1-5 centimetres thick, with irregular bedding; at the top of the unit sand beds have small pods (5 by 10 centimetres) of pebbly fine sand; granular beds are traceable for more than 1 metre but are deformed; unit grades laterally into pebbly sand with some cobbles; lower contact gradational but clear.
5	2.5 - 3.25	Interbedded sand and pebble gravel: well-sorted fine sand beds up to 10 centimetres thick; some coarse pebbly sand beds (poorly defined); gravel is small to medium pebbles with a 50% silt to coarse sand matrix; clasts are mainly subangular (some large pebbles), some well-rounded pebbles (~20%); rare angular boulders; poorly sorted; unit grades to the west into a poorly sorted sandy gravel; lower contact is gradational.
4	2.0 - 2.5	Fine sand with some medium to coarse sand: sand is thinly bedded with internal laminae; minor silt laminae at the base; unit coarsens upward and laterally interfingers with sandy pebble gravel.
3	1.2 - 2.0	Granule to small-pebble gravel: channel-fill bedding defined by moderately sorted pebble beds; beds have a massive internal structure and coarse sand matrix; some very well sorted, laminated fine sand interbeds (1-10 centimetres thick); gravel beds and some coarse sand beds are 5-20 centimetres thick; sandy beds are better sorted and more laterally traceable than gravel beds; some moderately sorted small to medium-pebble gravel beds to the west; some synclinal deformation (ice wedge cast?); lower contact is sharp and trough shaped (but no pebble lag).
2	0.2 - 1.2	Medium to large-pebble gravels interbedded with granule and medium to coarse sand beds: crude horizontal to inclined bedding; pebble beds are 5-10 centimetres thick; other beds are 3-10 centimetres thick; some small-pebble, partly openwork beds (partially cemented); pebbles are subangular to subrounded; rare boulders; unit is mostly medium pebbles (poorly sorted; up to 70% matrix of silt to coarse sand); large-pebble beds appear to be overlain by successively finer units; lower contact is scoured, trough shaped with coarse small to large-pebble lag.
1	0 - 0.2	Medium to fine sand: some coarse sand beds (1-3 centimetres thick); parallel, subhorizontal bedding; well sorted; lower contact covered.

Depth to bedrock at this site is 40 metres, lower units are apparently cleaner gravels. Drill records and past excavation indicate 14 metres of pea gravel (with relatively low gold values) and then bouldery gravels that are 6 metres thick.

Section 8921B (Lynn Gulch Section)

Location: This section is located on a south-facing wall in the same pit as Section 8921A but about 30 metres to the north. Figure 23 is a stratigraphic column of this section.

Unit	Height above base (m)	Description:
11	10.6 - 11.6	Diamicton: matrix supported; sand-silt-clay (loamy) matrix; dark grey-black; about 60% cobbles; even distribution of clasts from granules to boulders; noticeably striated clasts; subangular to subrounded; loose, not well compacted; lower contact appears to be trough shaped, infills a previously eroded channel and is gradational; in places the diamicton is interbedded with sandy poorly sorted gravel. Pebble lithologies, siltstone(pyritized, greyish) 48%, unidentifiable, strongly oxidized rocks 12%, andesite (greenish grey) 12%, quartzite 8%, basalt (pyritized) 8%, vein quartz 4%, mudstone (pyritized, dark black, laminated) 4%, fine sandstone (reddish) 4%.
10	9.1 - 10.6	Large-pebble to cobble gravel: similar to Unit 8 except ungraded, has more matrix and fewer large clasts, but still has some clasts up to boulder size; undulatory, indistinct lower contact.
9	8.1 - 9.1	Poorly sorted large-pebble gravel: similar to Unit 7; poorly exposed; almost matrix supported; clear and horizontal lower contact.
8	5.6 - 8.1	Large-pebble to cobble gravel: very crude horizontal strata; very poor imbrication suggesting flow to the northeast (75°); unit generally fines upwards; ~60% large pebbles and coarser; clast supported; matrix is fine sand and coarser; clasts are rounded to subangular; lower contact is gently scoured and marked by large cobbles and boulders. Pebble lithologies, pyritiferous siltstone 28%, greenstones (fine to medium grained) 28%, fine sandstone 12%, basalt 8%, andesite 8%, quartzite 8%, diorite 4%, gneiss 4%.
7	4.6 - 5.6	Large-pebble gravel: sand matrix; clasts up to large cobbles; poorly sorted; poorly exposed; appears massive; matrix supported (?); Units 6 and 7 contain a 3-metre diameter pyritized siltstone boulder with striated surfaces.
6	3.8 - 4.6	Medium-pebble gravel: similar to Unit 5 except horizontal laminae, well-sorted fine sandy beds up to 15 centimetres thick and occasional large-pebble to cobble concentrations.
5	1.8 - 3.8	Medium-pebble gravel: crude planar cross-stratification dipping 18° to the southeast (150°); clast supported; some large and small pebble beds; very well sorted fine sand matrix at base; beds are ~20-30 centimetres thick; beds poorly defined and consist of medium to large-pebble gravel with some granular beds; moderately sorted; clasts are subrounded; minor fine to medium, moderately sorted sand beds.

4	1.7 - 1.8	Medium sands: horizontal to low-angle trough crosslaminations; minor very well sorted fine sand beds at the base; well sorted; bed is laterally traceable for tens of metres; lower contact is sharp and horizontal.
3	1.5 - 1.7	Medium-pebble gravel: crude horizontal stratification; imbricated crudely suggesting flow to the north (345°); clast supported; poorly to moderately sorted; mixture of fine sand and coarser in matrix; clasts are up to 10 centimetres diameter, tend to lie flat and are mostly subrounded; unit forms a trough-shaped lens; extends for about 10 metres; lower contact is gradational.
2	1.0 - 1.5	Large-cobble to boulder gravel: clast supported; massive; some large-clast clusters; poorly to moderately sorted; matrix of medium sand and coarser; some mud at the base; mud in places occurs as 1-centimetre-thick coatings on larger clasts and is locally injected down into the underlying unit; unit thickness is irregular, thickening up to 1 metre in places; boulder clusters occur in poorly imbricated manner which indicate flow to the west at 310°; boulders are mostly subrounded to well rounded.
1	0 - 1.0	Medium-pebble gravel: crude horizontal bedding; poorly imbricated indicating a paleoflow to the northeast (60°); clast supported; moderately to poorly sorted; clasts are up to large pebbles; clasts mostly subangular but range from angular to subrounded with a few rounded clasts.

Section 8921C (Lower Lyne Gulch Section)

Location: Located near the northern side of the active part of the Spanish Mountain mine on the west bank of Lyne Gulch about 150 metres north of 8921B.

Unit	Height above base (m)	Description:
6	9.5 - 11.5	Cobble gravel: rare large boulders; lens-shaped deposit; scoured lower contact.
5	7.5 - 9.5	Cobble-boulder gravel: unit fines upward, coarsest boulders are located near the base; lower contact is subhorizontal and erosional.
4	5.5 - 7.5	Cobble-boulder gravel: large boulders tend to occur near the base of the unit; boulders are up to 1 metre diameter; 30% matrix; a broad band of manganese staining in the upper part; lower contact is defined by the clast concentrations, scoured and subhorizontal.
3	4.0 - 5.5	Large-boulder gravel: very poorly sorted; massive; coarser clasts occur near the base, up to 75 centimetres diameter; possible imbrication of clustered boulders at the base suggesting flow to the northwest; lower contact is subhorizontal and defined by concentrations of large clasts.
2	3.5 - 4.0	Diamicton: matrix supported; cobbly lag at base fining upward into small and medium-sized pebbles; clasts are subrounded to rounded; up to 50% matrix, mostly fine sand and silt; laterally discontinuous unit; lens shaped; lower contact is undulatory.
1	0 - 3.5	Large-boulder gravel: very poorly sorted; more than 50% of the boulders have diameters of 1.5 to 2.0 metres; most of the boulders are pyritiferous phyllite or intermediate intrusives, phyllite clasts are angular to subangular, intrusive blocks are mostly subrounded and have a deeply weathered rind (to a white powder) up to 50 centimetres thick; boulders have possible imbrication, suggests flow to the northwest (310°); clasts are sometimes strongly oxidized; matrix consists of pebbles and cobbles, mostly subrounded, and fine sands and silts, no medium and coarse sand; in places in the matrix there are well-sorted silt and fine sand beds, laminated and strongly deformed, particularly common around the margins of large clasts; sorted layers of laminated clays, 1 millimetre thick, silts up to 2 centimetres thick and fine sands and silts up to 10 centimetres thick and some granular medium sand beds that are 2 centimetres thick and occur around the outside edges of the large boulders and are generally thicker at the base of the boulder and thinner or absent at the top; in the lee of the boulders (downstream) the pebble matrix is bedded in places, beds are 10-20 centimetres thick and are moderately to poorly sorted with minor, thin, partially openwork small to medium-pebble gravel; clasts in these beds tend to lie horizontal and beds dip up to 15° to the northwest (310°) whereas clasts in the unsorted part of the matrix are unoriented; near the top of the unit there is a bed of moderately sorted, medium to coarse sand and granular sand beds 50 centimetres thick, gently inclined to horizontally stratified, beds are 1-10 centimetres thick with fine internal laminations; lower contact is covered.

Section 8921D (Ambler's Pit Section)

Location: Located approximately 150 metres west of Lyne Gulch (Sections 8921A and B) along a north-trending gully along a small abandoned road on the south side of a large open-pit mine.

Unit	Height above base (m)	Description:
2	3.0 - 5.5	Diamicton: matrix supported; grey colour; matrix is silty with some clay and sand; appears horizontally fissile and stratified; localized irregular, subhorizontal lenses of fine to medium sandy diamicton up to 20 centimetres thick; clasts are pebbles to boulders, subangular to subrounded; abundant striated clasts; local horizontal bedding defined by large-pebble and cobble concentrations and by moderately sorted sandy pebble-gravel beds, fine to coarse sand beds and some granular

		beds, beds are 5-20 centimetres thick and traceable for over 2 metres; local thin, horizontal fine sand laminae up to 1 centimetre thick; irregularly shaped, horizontally stratified small gravelly lenses with indistinct lower contacts and clear upper contacts, some have openwork areas; some beds are traced for up to 10 metres along a cobble-boulder lag; diamicton sample 8964 taken at 1-metre depth; unit thickness is relatively uniform over a wide area (hundreds of metres); lower contact is horizontal, may be interbedded or clear.
1	0 - 3.0	Fine to coarse sand and silt: well sorted; beds are 1-10 centimetres thick, laminated and horizontal to trough crossbedded; sometimes interbedded with matrix-supported, medium to large pebbly sand and clast-supported, small to medium-pebble gravel with a fine sand matrix; beds are laterally discontinuous; sand beds are deformed where they are in contact with a near-vertical, openwork medium to large-pebble gravel lens that is 1 metre high and 25 centimetres wide; beds on both sides of the lens are correlatable; there is a pebbly sand bed that contains a large clast of diamicton which is dark grey, silty, matrix supported, has angular clasts up to small cobbles, some of which are striated; diamicton blocks or clasts are common in the adjacent gravel; striated clasts occur throughout this unit; lower contact is covered.

Section 8921E (Upper Lynn Gulch Section)

Location: This section is located on a north-trending temporary mine road cut along Lynn Gulch in the same pit as Section 8921A but about 25 metres to the west.

Unit	Height above base (m)	Description:
4	4.5 - 7.5	Diamicton: very weakly stratified to massive; matrix supported; silty sand matrix; dark grey-black; loose; clasts up to boulder size; noticeably more striated clasts than underlying units.
3	1.5 - 4.5	Sandy cobble to boulder gravel: crude horizontal stratification; clast supported; poorly sorted; unit fines upward into poorly sorted sandy gravel; lower contact gradational.
2	1.0 - 1.5	Fine sand: horizontally laminated; well sorted; some moderately sorted coarse sand beds at the top of unit; unit is lens shaped; lower contact clear and trough shaped.
1	0 - 1.0	Sandy cobble gravel: crude horizontal bedding; clast supported; poorly sorted; lower contact covered.

Section 9021 (Oliver Gulch Section)

Location: Located approximately 150 metres northeast of Section 8921A along a north-trending gully known as Oliver Gulch.

Unit	Height above base (m)	Description:
5	7.0 - 9.0	Diamicton: similar to Unit 3.
4	6.0 - 7.0	Large-pebble gravel: matrix filled with fine to coarse sand; poorly sorted; unit is laterally discontinuous and grades into deposits similar to Unit 2; lower contact sharp and undulatory.
3	3.5 - 6.0	Silty diamicton: matrix supported; matrix of sand, silt and clay; clasts are subangular to subrounded; mostly up to small cobbles; numerous irregular lenses of fine sands that are 5-20 centimetres thick and 40-100 centimetres wide dip up to 40° to the northeast; concentrations of cobble gravel occur at the base of the unit with some openwork beds of medium-pebble gravel; clasts moderately well rounded; some minor manganese and iron staining; gravel lenses are up to 1 metre thick and several metres wide but are discontinuous; gravel is mostly poorly sorted with a fine sand and coarser matrix (matrix filled). In places the lower 50 centimetres is stratified with some well-sorted medium-sand beds that are 2-10 centimetres thick; unit is laterally discontinuous and grades into deposits similar to Unit 2; lower contact sharp and highly undulatory and dips to the west (310°).
2	1.0 - 3.5	Diamicton and interbedded gravelly fine sand with minor silt and silty sand gravel: some well-sorted fine sand lenses that dip steeply to the east (085°) at approximately 65°; diamicton poorly sorted and matrix supported; gravelly sand layers have 30% subangular to subrounded clasts; sandy gravel layers have about 70% clasts; beds are discontinuous; some small lenses of small to medium-pebble gravel, matrix filled and some almost openwork; pebbles are mainly local schists and quartzites and a few vein quartz and igneous clasts; lower contact is covered. In the bottom of Oliver Gulch the bedrock is overlain by numerous boulders up to 3 metres in diameter, mostly subangular to subrounded oxidized quartzites (~45%) and pyritic argillite/phyllite (~45%) and subrounded to rounded metasediments and metavolcanics (~10%).
1	0 - 1.0	Bedrock: black phyllite with abundant oxidized pyrite; strongly fractured parallel to foliation; foliation dips at 21° toward the northeast (025°); some vertical fracturing; about 100 centimetres of bedrock exposed; upper surface of bedrock rises to the west (290°).

SITE 22 - FOUR MILE CREEK (Keithley Creek)

Owner/operator: Lou Kovacs
NTS: 93 A/14 Cariboo Lake
Latitude & Longitude: 52°46'N, 121°26'W
UTM: 5848300 m N, 605600 m E
Year of property visit: 1990

Site Description:

The present operation at this property is mining at the head of an old hydraulic pit (Engineers Pit), located along Keithley Creek near the mouth of Four Mile Creek. There are old sluices and wingdam structures in the base of the pit and some gold has been recovered by underground mining in the past. The current operation is removing material down to the bedrock surface at the base of the old channel, with the mine expanding up into the headwall of the old hydraulic pit.

Section 9022A

Location: Located on the west side of the mine at an elevation several metres above the top of Section 9022B and approximately 20 metres above bedrock outcrops at the base of the active pit.

Unit	Height above base (m)	Description:
13	16.0 - 45.0	Diamicton, gravels, sands and silts: poorly exposed; inaccessible; some clay; soil development at the top of the section.
12	6.15 - 16.0	Sands and gravels: stratified.
11	4.15 - 6.15	Silts and clays: brecciated and abundant well-developed slickensides dipping south.
10	3.15 - 4.15	Cobble gravel fining upward to small-pebble gravel: some crude horizontal bedding; poorly exposed; weakly limonite stained especially near the top of the unit; also some manganese staining.
9	2.9 - 3.15	Pebbly fine to medium sands; crude bedding; weakly limonite stained.
8	2.8 - 2.9	Medium-pebble gravel: unit forms a small trough-shaped lens; openwork; manganese stained.
7	2.65 - 2.8	Small pebbly fine sands: partially oxidized.
6	2.55 - 2.65	Medium-pebble gravel: matrix filled with fine to medium sands; sporadic oxidation.
5	2.4 - 2.55	Fine sands: trough crosslaminated; sporadic oxidation.
4	2.0 - 2.4	Interbedded medium to coarse sand and small to medium pebbles: low-angle trough crossbeds to subhorizontal beds; unit is trough shaped; beds are 2-10 centimetres thick; iron and manganese staining on most beds; gravel is openwork; small pockets of pebbly silt and fine sand occur near the base of the unit or top of preceding unit (poorly exposed); lower contact is interbedded with Unit 5.
3	1.3 - 2.0	Large-pebble to small-cobble gravel: poorly sorted; clast supported; matrix filled with fine sand and coarser; limonite stained; random fabric; clasts are angular to subangular and subrounded, dominantly subangular; clasts up to boulders (50 centimetres diameter); some very crude bedding; occasional blocks or irregular lenses of medium sand; lower contact erosional, scoured, unconformably crosscuts bedding. Pebble lithology sample 9027.
2	0.5 - 1.3	Very fine sand and silt: horizontally laminated; some convoluted laminations; sandy laminations are limonite stained; silty laminations are unoxidized; some beds of medium sand, up to 2 centimetres thick, occur in the upper 10 centimetres; lower contact sharp and planar.
1	0 - 0.5	Interbedded medium sand and small pebbly coarse sand: horizontally stratified but beds dip up to 5° toward the southeast (160°); medium sand well sorted and coarse sand poorly sorted; some fining-upward beds of small pebbly coarse sand; medium sandy beds have laminae up to 0.5 centimetre thick; beds up to 20 centimetres thick; strong reddish iron oxidation; lower contact covered.

Section 9022B

Location: Located at the east side of the mine. The top of the section is several metres below the base of Section 9022A.

Unit	Height above base (m)	Description:
2	0.5 - 10.0	Large-pebble to cobble gravel: poorly exposed; horizontally bedded; interbedded moderately well sorted fine sand lenses; gravel is poorly sorted; sandy beds are 25 centimetres thick, gravelly beds are 1-4 metres thick; matrix filled with silt and coarser; loose and unconsolidated, slumped; possibly tailings; some large boulders of bedrock and a few rounded boulders; small irregular lenses of silt and clay; minor openwork beds; beds dip toward the centre of the valley (215°) up to 15°; unit also contains pieces of wood; lower contact is covered.
1	0 - 0.5	Bedrock: interbedded black argillaceous schists and gritty quartzite; foliation dips 29° to the south; upper surface rises to the east at 45°; lower contact covered.

ABANDONED, HIGH-LEVEL PALEOCHANNELS (LOCATION 23)

SITE 23 - STREICEK MINE

Owner/operator: Werner Streicek
NTS: 93H/4 Wells
Latitude & Longitude: 53°05'N, 121°41'W
UTM: 5881500 m N, 588500 m E
Year of property visit: 1989, 1990

Site Description:

This property is located on a high bench at the confluence of the Devils Lake Creek and Slough Creek valleys. A composite stratigraphic column of the mined deposits and overburden sequence at this property is given in Figure 20.

Section 8923

Location: This section is located on the southwest side of active part of the open-pit mine.

Unit	Height above base (m)	Description:
3	3.2 - 4.5	Diamicton: massive; sandy-silt matrix; matrix supported; 20% clasts, mostly pebbles with a few cobbles and boulders; some with striated clasts; pebble lithologies are varied, 32% quartzite, 24% slaty schist, 16% carbonates, 12% vein quartz, 8% gneiss, 4% siltstone and 4% igneous rocks; lower contact horizontal and gradational.
2	1.5 - 3.2	Pebble gravel: clast supported; well imbricated; crude horizontal bedding; bedding is defined by slightly better sorted layers which are preferentially oxidized; matrix sand to granules at base to silty sand at the top; compact (over consolidated); clasts mainly small to large pebbles in the lower half and large pebbles to small cobbles in the upper half of the unit; clasts are angular to subrounded and mainly blades and discs; pebble orientations are distinctly bimodal, strongly oriented toward northwest (320°-330°) and moderately oriented toward north-northeast (014°-061°); the coarser gravel at the top of the unit forms a trough-shaped lens which grades laterally into a poorly sorted matrix filled gravel; pebble lithologies, 16% quartzite, 28% quartz gneiss, 48% black slaty schist and 8% vein quartz. Pebble fabric 892313b taken at 2.5 metres.
1	0 - 1.5	Pebble gravel: horizontally stratified to low-angle planar cross-stratified; clasts moderately imbricated, dipping to the southwest; clasts angular to subrounded and mainly pebbles with a few angular cobbles; sandy matrix; some better sorted small-pebble beds; lower contact at water level. Pebble fabric 892313a taken at 0.5 metre.

Section 9023

Location: This section is located on the northeast side of the active part of the open-pit mine. Units 1 to 3 were measured in a backhoe pit in the mine centre. Units 4 to 10 were measured along a series of bench cuts rising up from the mine centre to the northern margin of the open pit.

Unit	Height above base (m)	Description:
10	20.4 - 24.4	Diamicton: matrix supported; unoxidized (dark grey-blue); clasts are subangular to rounded, about 20-30% clasts; mostly pebbles, rare cobbles, no boulders; horizontal partings; silt-clay matrix; upper metre is more sandy; some sand lenses; one lens is well sorted, trough shaped, 20 centimetres thick and 2 metres wide, and forms a large trough about 1 metre high; lower contact is sharp, clear and horizontal.
9	19.5 - 20.4	Diamicton: matrix supported; oxidized (very light grey); abundant striated clasts; clasts subangular to rounded; matrix is dry clay and silt; compact; horizontal lower contact.
8	18.0 - 19.5	Interbedded fine sands and pebble gravels with subunits described upwards from the base of the unit, measured in centimetres:
	0-15	Fine sand: horizontally stratified; very well sorted.
	15-20	Sandy small-pebble gravel: oxidized.
	20-30	Fine sand: horizontally stratified; well sorted; scattered pebbles.
	30-70	Sandy small to medium-pebble gravel: horizontally stratified; well imbricated with paleoflow to the north; one fine sandy lens at 50 centimetres is 2 centimetres thick by 2 metres wide; partially oxidized; better sorted units more oxidized.

	70-90	Fine sand: horizontally laminated; scattered pebbles; pebbles more common toward the top; minor silt/clay laminae in unit.
	90-140	Pebbly sand grading into a sandy medium pebbly gravel: matrix supported; chaotic fabric; poorly sorted.
	140-150	Small-pebble to small-cobble gravel: subrounded to well-rounded clasts; unit is a lens about 3 metres wide; almost openwork.
7	15.0 - 18.0	Fine-sandy pebble gravel: crudely stratified; poorly sorted; similar to Unit 3 but with fewer shale clasts.
6	8.0 - 15.0	Medium to large-pebble gravel: abundant silty, fine sand matrix; crudely stratified; poorly sorted with minor beds of moderately sorted small and medium-pebble gravel; clasts mostly angular phyllite, some rounded quartzites; some small oxidized openwork small-pebble gravel lenses between larger clasts; clasts imbricated indicating northerly paleoflow (350-010°); in the upper few metres of the unit there are some lenses of moderately sorted pebble gravel and some subhorizontal stratification. Pebble fabric 902319.
5	5.7 - 8.0	Medium-pebble gravel: 10-20% large pebbles and cobbles (outsized clasts 'floating' in a finer gravel matrix); large pebbles and cobbles are mostly weathered angular local phyllite; medium pebbles mostly subangular to angular but some rounded vein quartz and quartzite; limonite stained; lower contact conformable.
4	4.0 - 5.7	Bouldery gravel: channel-fill bedding; unit is lens shaped and dips sharply to the west (290°) at 45° (paleochannel orientation is about 020°); gravels poorly sorted; matrix is clay and coarser; numerous local clasts of shale and some rounded distal clasts; there is a concentration of cobble-sized phyllites at the top of this unit (bottom of next); imbrication indicates flow to the north. Pebble lithologies, phyllite 52%, quartzite 16%, vein quartz 12%, quartz gneiss 8%, schist 8%, gneiss 2%, metavolcanic 2%.
3	2.5 - 4.0	Bouldery gravel: channel-fill bedding; numerous clasts of broken angular phyllite; some large boulders; matrix of fine sand and coarser; poorly sorted; pebbles mainly quartz gneiss, quartzite, schist and vein quartz; unit is similar to Unit 4 but was less well exposed (Units 1 to 3 were measured in a backhoe pit in the 'channel' centre).
2	1.0 - 2.5	Cobble to pebble gravel: horizontal bedding and trough crossbedding; some openwork beds; unit is similar to Unit 4 but was less well exposed; lower contact dips towards the channel centre (northwest).
1	0 - 1.0	Boulder gravel: stratified; openwork; clasts well rounded to subrounded; few angular phyllites; lower contact covered.
	Bedrock:	Black shaly phyllite: some small 1-2 millimetre quartz veins; thinly bedded; some more massive beds about 20 centimetres thick; beds dip 35°towards 040°; upper surface has been smoothed by water washing (unit is not exposed at the section base, laterally underlies Units 4 and 5).

BURIED CHANNELS WITHIN MODERN VALLEYS (LOCATIONS 24 TO 31)

SITE 24 - LIGHTNING CREEK

Owner/operator: Gallery Resources Ltd.
NTS: 93G/1 Cottonwood
Latitude & Longitude: 53°02'N, 122°02'W
UTM: 5875000 m N, 5652000 m E
Year of property visit: 1990

Site Description:

This site is located on the south side of the Lightning Creek valley. Figure 28 is a composite stratigraphic column of three exposures: 9024A at the base of the section, 9024B in the middle, and 9024C at the top.

Section 9024A (Basal Section)

Location: This section is located at the east end of the mine at the base of a high bench on the south side of the river (Figure 28).

Unit	Height above base (m)	Description:
10	8.9 - 10.2+	Large-pebble to small-cobble gravel: similar to Unit 6; has a coarse-clast lag (mainly cobbles) at base; less well sorted than Units 6 and 8.
9	8.7 - 8.9	Large-pebble to small-cobble gravel: iron-manganese layer of openwork medium to large-pebble gravel with minor cobbles; similar to Unit 7.
8	7.9 - 8.7	Large-pebble to small-cobble gravel: similar to Unit 6; large-cobble lag at base.
7	7.7 - 7.9	Medium to large-pebble gravel: moderately well sorted; oxidized (iron stronger than manganese).
6	5.8 - 7.7	Large-pebble to small-cobble gravel: clasts up to small boulders; horizontally stratified; clast supported; moderately imbricated indicating paleoflow to the west; poorly to moderately sorted; matrix is fine sand and coarser; scattered-boulder lag at the base; some thin beds (<2 centimetres thick) of small-pebble gravel which are stained with iron and manganese oxides; manganese appears on top of the iron staining; overall the unit is weakly oxidized; clasts are rounded to well rounded; some small fine sand lenses 1 centimetre by 10 centimetres wide; beds are mostly 10-50 centimetres thick; unit thickens to the east, thins to the west; lower contact drops about 1 to 1.5 metres over 5-10 metres and is scoured and undulatory, crosscutting the underlying bedding; pebble lithologies, quartz gneiss 56%, vein quartz 12%, schist 8%, black phyllite 8%, gneiss 4%, quartzite 4%, metasediment/volcanic (metasiltstone?) 4%, slate 4%.
5	5.0 - 5.80	Medium to large-pebble gravel: horizontally bedded; some weak, small scoured troughs; moderately to well sorted; mostly openwork; basal 20 centimetres is medium pebbles with iron oxidization overlain by 10 centimetres of similar gravels with manganese oxides, 40 centimetres of large pebbles and small cobbles with minor iron oxidization, and 10 centimetres of medium to large pebbles with manganese oxides; clasts rounded to well rounded; bed contacts are clear; unit forms a broad trough; lower contact erosional.
4	4.15 - 5.0	Medium-pebble to boulder gravel: similar to Unit 2; boulder concentration near the top of bed; unit is as a trough-shaped lens about 20 metres wide which infills onto the lower trough-shaped unit (Unit 3); poorly sorted; lower contact is gradational.
3	3.75 - 4.15	Medium to large-pebble gravel: crude horizontal stratification; numerous openwork beds; moderately sorted; clasts well rounded; reddish oxidation with some manganese staining; unit is a large trough-shaped lens; lower contact erosional.
2	1.15 - 3.75	Medium-pebble to boulder gravel, mainly large pebbles: very crude horizontal stratification; imbrication very crude to chaotic; stratification defined by small lenses of moderately sorted sandy pebble gravel and minor concentrations of cobbles and boulders; some small openwork lenses of small to medium pebbles; a concentrated zone of larger clasts, mostly cobbles and boulders, occurs in the upper 50 centimetres; most of unit is poorly sorted; moderately sorted at base; matrix is mostly sands with some silt; openwork lenses occur particularly around large boulders; some silt lenses; about 5% boulders, 10% cobbles; clasts are subrounded to rounded; some angular clasts of shale and quartz; mottled red-brown (oxidation); larger clasts appear to be floating in a sand-pebble matrix; possibly a "hyperconcentrated flood flow" deposit (high-energy flow but not a debris flow as there is no clay and minor silt), probably a very high energy stream. Pebble lithology: gneiss 8%; metavolcanic, black, fine-grained 2%; quartzite 15%; limestone 2%; phyllite 5%; schist 10%; metasandstone, strongly weathered, quartzose 10%; quartz gneiss 25%; vein quartz 13%;

		fine-grained metasiltstone 2%; shale 5%; fine-grained diorite to gabbro (dark, small crystals, plagioclase, hornblende, pyroxene) 2%. Lower contact unconformable.
1	0 - 1.15	Interbedded medium to large-pebble pebble gravel and fine to medium sand: trough crossbedded; sand horizontally stratified; gravel mainly openwork with iron and manganese staining; sand well sorted; gravel moderately sorted; clasts well rounded to rounded; lower contact is erosional.
	Bedrock:	Fine-grained metavolcanic or metasediment: light greenish grey, relatively soft, (less than 5), massive, vertical and horizontal jointing, breaks into 10 to 30-centimetre blocks, locally silicified with small quartz veins, some shear surfaces with weak slickensides; possible near-vertical shear zone with fault gouge oriented at 100°; upper surface of the bedrock slopes 12° to the south (185°); lower contact covered.

Section 9024B (Road Section)

Location: This section was measured along a temporary mine road leading from the valley bottom to the top of the high bench on the south side of the river. The section base is approximately the same elevation as the top of Section 9024A but about 300 metres further west (Figure 28).

Unit	Height above base (m)	Description:
11	10.0 - 15.0	Covered.
10	8.0 - 10.0	Large-pebble to small-cobble gravel: crude horizontal stratification; fining upward; poorly to moderately sorted; better sorted and bedded in the upper part; some openwork beds.
9	7.0 - 8.0	Small-pebble gravel interbedded with medium to large-pebble gravel: beds are 10-20 centimetres thick; some openwork beds.
8	6.7 - 7.0	Coarse sand and pebbly sand: horizontally bedded; unit forms a very broad trough-shaped lens at least 15 metres wide; beds are 1-4 centimetres thick.
7	4.7 - 6.7	Large-pebble to small-cobble gravel: crude horizontal stratification; some boulders in the lower half of the unit; poorly to moderately sorted; better sorted and bedded in the upper 50 centimetres; some openwork beds near unit top.
6	4.2 - 4.7	Medium-pebble gravel: horizontally bedded, beds are 10-20 centimetres thick; moderately sorted, well imbricated.
5	3.6 - 4.2	Large-pebble gravel: horizontally bedded; some beds dip slightly to the west; well imbricated and suggests flow to the west at 300°, a(t), b(i) imbrication; moderately sorted; lower contact is horizontal.
4	3.3 - 3.6	Medium-pebble gravel: clast supported; openwork; lower contact clear and horizontal.
3	2.4 - 3.3	Medium to large-pebble gravel: clast supported; matrix filled; the unit forms a lens that fills the upper part of the same trough defined by Unit 2; clasts are subrounded to well rounded; poorly sorted; lower contact erosional; a cobble-boulder lag defines the lower contact.
2	1.6 - 2.4	Medium to large-pebble gravel: clast supported; matrix filled; unit is trough shaped and at least 5 metres wide; clasts are subrounded to well rounded; poorly sorted; lower contact erosional and defined by a cobble to boulder lag gravel.
1	0 - 1.6	Small-cobble gravel: clast supported; matrix filled; poorly sorted; matrix of fine sand and coarser; 50-70% large pebbles and coarser; clasts are subrounded to well rounded; lower contact covered.

Section 9024C (Upper Section)

Location: This section was measured at the top of the high bench on the south side of the river approximately 150 metres west (080°) of Section 9024B (Figure 28).

Unit	Height above base (m)	Description:
6	3.6 - 5.6	Sand and silt: horizontally laminated; well sorted; moderately to poorly exposed; rare large clasts; lower contact gradational.
5	2.9 - 3.6	Small-pebble to medium-pebble gravel interbedded with granular to small-pebble gravel: trough crossbedded; openwork; moderately to well sorted; lower contact is scoured.
4	1.3 - 2.9	Large-pebble to cobble gravel: subhorizontal scour-fill structures; poorly to moderately sorted; fining-upward sequences with cobble-boulder lags at the base (channel scours); some small lenses of well-sorted sands and small pebbles; strongly limonite stained in the lower half (contact with unoxidized material is undulatory).
3	1.2 - 1.3	Coarse sand: fines upward into horizontally laminated fine sand; unit forms a lens about 4 metres wide; well sorted.
2	0.9 - 1.2	Small to large-pebble gravel: interbedded small to medium pebbles with sandy large-pebble beds; trough cross-stratified; small to medium pebbles are openwork; sandy large-pebble beds are matrix filled; lower contact is scoured.
1	0 - 0.9	Medium to coarse sands: unit coarsens upward into coarse sand and granules with pebbles; trough cross-stratified; unit is lens shaped and is 10 metres wide with a maximum thickness of 1 metre.

SITE 25 - LIGHTNING CREEK

Owner/operator: Shirley McGuire
NTS: 93G/1 Cottonwood
Latitude & Longitude: 53°01'N, 122°00'W
UTM: 5875000 m N, 566500 m E
Year of property visit: 1989

Site Description:

This site is located along Lightning Creek about 0.5 kilometre upstream from Site 24. The property was inactive in 1989 but activity in recent years is indicated by several open pits on a low terrace above Lightning Creek.

Section 8925

Location: This section is located at the base of the south side of the valley on the margin of a terrace.

Unit	Height above base (m)	Description:
3	7.0 - 12.0+	Diamicton: massive; matrix supported; silty clay matrix; some moderately to poorly sorted sand beds in the lower 50 centimetres; lower contact sharp and planar and locally dips steeply downslope due to slumping.
2	4.0 - 7.0	Fine sand: interbedded silt and clay in the upper 50 centimetres; horizontally laminated; well sorted; lower contact is scoured.
1	0 - 4.0	Silt and clay: horizontally laminated; well sorted; lower contact covered.

SITE 26 - LIGHTNING CREEK - WINGDAM

Owner/operator: Gold Ridge Resources Inc.
NTS: 93H/4 Wells
Latitude & Longitude: 53°02'N, 121°58' W
UTM: 5877200 m N, 569000 m E
Year of property visit: 1989

Site Description:

This site has been the focus of several underground mining attempts to exploit deeply buried auriferous gravels. Past attempts at mining the lower gravels have failed due to groundwater problems and slumping of glaciolacustrine deposits into the mine workings. Gold Ridge Resources Inc. began mining at the Wingdam property in the winter of 1990-91. No exposures were open for examination at the time of the property visit. The company was successful in dewatering the gravel aquifer and an adit through bedrock into the gravels has been completed.

SITE 27 - EIGHT MILE LAKE

Owner/operator: Church Logging / John Knutsen
NTS: 93H/4 Wells
Latitude & Longitude: 53°09'N, 121°31'W
UTM: 5889700 m N, 598000 m E
Year of property visit: 1989

Site Description:

The Eight Mile Lake property was the focus of a large operation in the winter of 1988-89 but was mainly in a reclamation phase by the summer of 1989 when visited. Suction dredging and a hydraulic mining operation at the southwest end of the lake have been conducted at this site in the past. No exposures were open for examination at the time of the property visit.

SITE 28 - SUMMIT CREEK

Owner/operator: Frank Nestel
NTS: 93H/4 Wells
Latitude & Longitude: 53°09'N, 121°32'W
UTM: 588900 m N, 598800 m E
Year of property visit: 1989

Site Description:

Recent activity at this site has targeted some small buried bedrock channels. There are several open pits in the area but no good exposures.

SITE 29 - WILLIAMS CREEK

Owner/operator: Bert Ball (Wilderness Explorations Ltd.)
NTS: 93H/4 Wells
Latitude & Longitude: 53°05'N, 121°31'W
UTM: 5882100 m N, 600500 m E
Year of property visit: 1989, 1990

Site Description:

The Ballarat mine is located directly east of the Barkerville airfield about 400 metres northeast of Williams Creek. The property lies at the east end of a small pass that is occupied by Weldon Lake and joins Williams Creek and Pleasant Valley Creek. Sections 8929R and 8929A to 8929F outcrop along a mine highwall on the east side of the property. A north-south cross-section of the exposure illustrating the major stratigraphic units and the locations of these sections is provided in Figure 30. Sections 8929NE and 8929E were measured in an open pit about 250 metres west of the highwall.

Section 8929NE (Northeast Wall Section)

Location: This section was measured along the northeast wall of the main water supply pit.

Unit	Height above base (m)	Description:
9	8.1 - 16.1	Cobble and pebble gravel: cobble gravel occurs at the base and grades up into matrix rich (50%) pebbly gravels and sands that are capped by a soil horizon; equivalent to East Wall section, Units 7 and 8.
8	6.4 - 8.1	Large-pebble gravel: some cobbles; crude horizontal stratification; lower contact is gradational.
7	4.4 - 6.4	Large-pebble and cobble gravel: very poorly sorted; 50% large pebbles and cobbles, 20-40% small and medium pebbles and 10-20% silty sand matrix; lower contact is gradational.
6	2.9 - 4.4	Medium-pebble to small-cobble gravel: beds are crudely trough shaped and are traceable for about 5 metres; medium-pebble beds are moderately sorted; large-pebble and cobble beds have a coarse sand matrix; beds are laterally gradational; cobbles tend to occur in clusters and at the base of the unit; large-pebble beds occur in poorly defined trough-shaped concentrations up to 2 metres wide.
5	2.4 - 2.9	Medium to coarse sands: trough crosslaminations; stratification is poorly preserved; well-sorted minor granule beds; unit is a lens 7 metres wide; lower contact is clear and conforms to the concave upper surface of the underlying unit, contact dips at 10° to the west (285°).
4	1.9 - 2.4	Large-pebble gravel: clasts up to small cobbles; 50% small and medium pebbles; matrix is mostly coarse sand with minor medium and fine sands and silt; poorly sorted; massive; weakly imbricated to chaotic, suggests flow to the west; clasts are angular to rounded, mostly subrounded; up to 50% clasts are locally derived and most large pebbles are subrounded and probably glacially derived, commonly limestones; unit conforms to the shape of the underlying units; pebble lithologies (sample 8952), 56% limestone, 16% phyllite, 8% gabbro, 8% intermediate igneous, 4% vein quartz, 4% schist, 4% siltstone; lower contact is erosional, sharp and scoured, scours are up to 1 metre deep and at least 10 metres wide.
3	1.8 - 1.9	Very fine sand and silt: locally laminated; laminations cut by clasts penetrating from the overlying unit; lower contact is conformable and gradational with the underlying unit.
2	0.9 - 1.8	Diamicton: matrix supported; fine sandy silt matrix; 20% clasts, angular to subrounded, mostly small to medium pebbles and some large clasts; some striated clasts; limestone and schist clasts common; tabular clasts tend to lie horizontally and there is an increase in angular clasts of local lithology toward the base of the unit; in the lower 20 centimetres there are horizontal beds that are defined by discontinuous diamicton lenses of variable clast content; unit is a trough-shaped lens that pinches out to the northwest and thickens to the southeast; the lower contact is interbedded.
1	0 - 0.9	Breccia: horizontally bedded, beds of thick brecciated talc schist,10 centimetres thick, pale yellow colour; ~80% recognizable clasts and 20% ground up matrix; some concentrations of granular to

medium-pebble vein quartz that occur in concentrated lenses or pods; beds are mostly 20-40 centimetres thick consisting of flat-lying angular blocks which are 5-20 centimetres thick and up to 3 metres long; blocks appear boudinaged and consist of calcareous quartz-mica schist which is thinly bedded or foliated; blocks are commonly folded or irregularly oriented; in places there are some larger blocks of vein quartz (up to large-pebble size); a thin clay layer, 1 centimetre thick, occurs near the base of the unit; bedrock sample 8951.

Bedrock: 25 centimetres of strongly weathered muscovite-quartz schist with garnets; poorly preserved.
25 centimetres of reddish quartzite (quartz and feldspar); thinly bedded, less than 1 centimetre thick; frequent muscovite layers; calcareous.
2 metres of biotite-muscovite schist with cubic pyrite; good fissility; possible calcareous crystals; strongly foliated, dips 13° to the northeast (040°); bedrock sample 8954.
25 centimetres of reddish grey quartzite, quartz with weathered feldspars and micas; thickly bedded, up to 10 centimetres.

Section 8929East (East Wall Composite Section)

Location: This is a composite section measured along the east wall of the main water supply pit.

Unit	Height above base (m)	Description:
8	8.0 - 10.0	Large-cobble gravel: abundant tabular, angular clasts; crude horizontal stratification; clasts tend to lie flat; abundant local quartzites; clasts are angular to rounded, mostly angular to subrounded; some moderately sorted small-pebble beds and some poorly sorted medium and large-pebble beds; occasional striated clasts; lower contact is sharp and horizontal, in part lying on bedrock to the north and to the south overlying Units 1-7; separated from Units 1-7 by a brecciated bedrock lens about 20 centimetres thick which pinches out to the south.
7	3.0 - 8.0	Large cobble-boulder gravel: poorly sorted; some finer pebbly interbeds; 10% matrix of fine sand; 25% granules to large pebbles; clasts are angular to rounded, boulders are mostly subrounded; crude stratification, dips to the south at 5-10°; boulder and cobble beds are up to 2 metres thick; beds without boulders and only rare cobbles are up to 1 metre thick; beds are discontinuous and have gradational boundaries; beds are chaotic at the base, possibly imbricated and as the unit fines upward become better stratified, some beds are horizontally stratified near the top; pebble lithologies, 42% quartzite, 22% gabbro, 12% vein quartz, 8% schist, 8% quartz gneiss, 4% limestone, 4% greenstone; Units 7 and 8 are correlatable to the Northeast Wall section, Unit 9.
6	2.6 - 3.0	Small to medium-pebble gravels: moderately sorted; well bedded, 5-25 centimetres thick.
5	2.4 - 2.6	Medium to large-pebble gravels; clasts tend to lie flat; has a matrix of fine sand to granules; beds dip to the south at approximately 5°.
4	1.5 - 2.4	Small to medium-pebble gravels: moderately sorted; well bedded, 5-25 centimetres thick; beds dip to the south; lowest beds fill a trough and upper beds are planar.
3	1.2 - 1.5	Medium to large-pebble gravel: some small pebble beds 10 centimetres thick; clasts tend to lie flat; matrix of fine sand to granules, coarser beds tend to have a fine sand matrix; beds dip to the south 05°; beds are channellized, channel is about 50 centimetres deep and 2-5 metres wide.
2	0.5 - 1.2	Small-pebble gravel: moderately sorted; matrix of fine and some medium sands; crude inclined bedding dipping to the south.
1	0 - 0.5	Medium to large pebbly gravel: clast supported; fine to medium sand matrix; moderately sorted; clasts subangular to rounded; very compact deposit; disorganized structure; pebble lithologies, 32% quartzite, 16% biotite-quartz gneiss, 16% limestone, 12% schist, 8% chlorite schist, 8% siltstone, 4% gabbro, 4% intermediate igneous; lower contact covered.

Section 8929R (Road Section)

Location: This section is exposed at the north end of the main open pit (along the west side of a temporary mine road leading up to the old hydraulic pit south of the mine).

Unit	Height above base (m)	Description:
3	2.6 - 6.6	Diamicton: matrix supported; light olive-grey (5Y 6/2) to light grey (5Y 7/2); 25% clasts, small-pebble to small-cobble sized, angular to rounded, some broken clasts, some striated; matrix of clays and silts with sands; possibly crudely stratified, suggested by variations in clast content and matrix texture; beds are 3 centimetres to 1 metre thick; some well-developed sand, silt and clay lenses; one clay lens with incorporated silt balls; clay layers sometimes have well-preserved horizontal laminations; sand and silt lenses sometimes have convoluted laminations; layers are traceable for up to 2 metres and have interbedded upper and lower contacts; occasional gravelly layers; clay shadows or linings on clasts common; pebble lithologies, 39% quartzite, 14% quartz gneiss, 14% vein quartz, 14% limestone, 11% schist, 4% diorite, 4% mafic igneous; diamicton sample 8917; pebble fabric 892903 taken at 3.1 metres; lower contact is interbedded and gradational.

2	2.5 - 2.6	Diamicton: matrix supported; olive-grey (5Y 4/2 to 5Y 5/2); interbedded with units above and below; some downward intrusions of the upper diamicton through this bed into the lower diamicton; one tongue is 40-50 centimetres long by 5-8 centimetres wide; diamicton sample 8916; clear and depositional contacts.
1	0 - 2.5	Diamicton: matrix supported; dark greyish brown (2.5Y 4/2); clasts up to boulder size, mostly small pebbles to cobbles, angular to subrounded; clasts commonly striated, many shattered or broken; matrix of sandy silt; ~40% clasts; breaks irregularly, not fissile or blocky; clay shadows or linings around clasts common especially larger clasts; very hard when dry; diamicton sample 8915; pebble fabric 892901 taken at 1 metre and 892902 was taken at 2 metres; lower contact is covered.

Section 8929A (Section A)

Location: This section was measured at the northernmost end of the east (main) highwall in the active part of the main open pit (Figure 30).

Unit	Height above base (m)	Description:
8	11.2 - 12.0	Fine to medium sands: well sorted; massive to horizontally stratified, beds marked by coarser oxidized layers and by buried Ah horizons in the upper 30 centimetres; scattered pebbles; unit is capped by a modern soil with logs and other organics; unit is lens shaped and about 10 metres wide; lower contact is gradational.
7	9.8 - 11.2	Diamicton: matrix supported; sandy silt matrix; apparently massive, structureless; some vertical joints 10-20 centimetres apart; 30-40% clasts, subangular to subrounded, striations common; mostly pebbles, rare cobbles and boulders; moderately compact; minor sorted silt laminae, irregular or subhorizontal, about 10 centimetres long; lower contact is gradational.
6	7.8 - 9.8	Diamicton: matrix supported; silty matrix with sand; vertical joints 10-20 centimetres apart; horizontal partings, subhorizontal and irregularly spaced; some partings have slickensided surfaces (277°); clasts commonly striated and faceted (268°, 270°, 302°, 302°, 318°); unit thickens to the south to 4 metres; pebble lithologies, 36% limestone, 18% schist, 18% quartzite, 16% mafic intrusive, 6% siltstone, 4% vein quartz, 2% ironstone; lower contact is sharp where observable.
5	7.15 - 7.8	Diamicton: matrix supported; matrix is sandy silt, feels slippery, abundant abraded talc schist bedrock; 10-20% clasts, often very angular; numerous steeply dipping clasts (imbricated), mostly up to small-cobble size; red-brown colour; lower contact is clear and conformable.
4	7.05 - 7.15	Medium to coarse sand: discontinuous lens about 2 metres wide
3	6.5 - 7.05	Granule to medium-pebble gravel: poorly sorted; massive to crude horizontal stratification; unit is lens shaped, pinches out over 10 metres; lower contact is gradational.
2	6.0 - 6.5	Granule to large cobbly gravel, 80% clasts, 40% cobbles; matrix of sands with silts; pinches out over 15 metres, conforms to the unit above; upper contact is marked by a scattered cobble concentration; lower contact is gradational.
1	0 - 6.0	Small to medium-pebble gravel: poorly sorted; 20% large pebbles and 5% cobbles and boulders; clasts are rounded to well rounded; medium to coarse sand and silt matrix; crudely stratified; a pod of cobble-boulder gravel is 80 centimetres thick and 300 centimetres long, clasts are mostly limestone, angular to subrounded, matrix of fine to medium sand; a matrix-supported, poorly sorted silt to pebble diamicton lens is present, has some weak convoluted laminations; some moderately sorted, openwork medium-pebble gravel beds; pebble lithologies, 32% quartzite, 22% quartz gneiss, 20% schist, 20% vein quartz, 4% chert, 2% sandstone; lower contact is covered; unit is bounded to the south by a steeply dipping bed of silt and fine sand that is massive or internally laminated, dipping 60° toward 250°; this sand separates Section A from Section B.

Section 8929B (Section B)

Location: This section was measured on the east (main) highwall in the active part of the open pit mine about 20 metres south of Section A (Figure 30).

Unit	Height above base (m)	Description:
10	8.0 - 11.0	Diamicton: matrix supported; sandy silt matrix; apparently massive; horizontal partings, irregularly spaced; some vertical joints 10-20 centimetres apart; 30-40% clasts, subangular to subrounded, striations common; mostly pebbles, rare cobbles and boulders; moderately compact; minor sorted silt laminae, irregular or subhorizontal, about 10 centimetres long; erosional lower contact.
9	4.75 - 8.0	Medium-pebble gravel: moderately sorted; medium sand matrix; rare large pebbles; deformed internal strata; beds are massive, 5-20 centimetres thick; beds dip 32-35° toward 220-260°; gradational lower contact.
8	4.0 - 4.75	Granule to small-pebble gravel: moderately sorted; well bedded, 5-15 centimetres thick; beds commonly deformed; dips conformable to above; gradational lower contact.
7	3.0 - 4.0	Coarse pebbly gravel: poorly to moderately sorted; medium sand matrix; beds dip to the southwest, gentler dips than above; scoured, erosional lower contact.

6	1.9 - 3.0	Granule to small-pebble gravel: well bedded 5-15 centimetres thick; beds deformed, dip to the southwest almost subhorizontal; gradational lower contact.
5	1.3 - 1.9	Coarse pebbly gravel: silty sand matrix; chaotic; irregular bed thickness; pebble lithologies, 32% quartz gneiss, 28% quartzite, 22% schist, 12% vein quartz, 4% mafic igneous, 2% diorite; deeply scoured lower contact, scours to 25 centimetres deep.
4	1.0 - 1.3	Pebbly sand: structureless; gradational lower contact.
3	0.5 - 1.0	Fine to coarse sand: crude horizontal strata; gradational lower contact.
2	0.25 - 0.5	Sandy pebbly gravels: gradational lower contact.
1	0 - 0.25	Coarse sand: gradational lower contact.

Section 8929C (Section C)

Location: This section was measured on the east (main) highwall in the active part of the open pit about 10 metres south of Section B (Figure 30).

Unit	Height above base (m)	Description:
6	7.0 - 13.0	Diamicton: matrix supported; sandy silt matrix; horizontal partings; some vertical joints 10-20 centimetres apart; 30-40% clasts, subangular to subrounded, striations common; mostly pebbles, rare cobbles and boulders; moderately compact; irregular or subhorizontal silt laminae; erosional lower contact.
5	5.0 - 7.0	Sandy pebble gravel: poorly sorted; mostly medium to large pebbles; clast supported with a sandy matrix; clasts are subangular to well rounded, mostly rounded.
4	4.5 - 5.0	Fine to medium sands: very well sorted; weak to moderate stratification; clay inclusions appear injected, irregular shaped; unit is siltier toward the base; sharply truncated to the north and south; lens is about 5 metres wide, dips at 18° to the northeast (040°).
3	2.5 - 4.5	Large-pebble gravel: almost matrix supported with poorly sorted silty sand and granule matrix; bed thickens to the south; pinches out to the north.
2	2.0 - 2.5	Granule to small-pebble gravel: moderately sorted; bed is truncated to the west by overlying gravel and rises to the south at 37°; truncated at the top by the overlying diamicton.
1	0 - 2.0	Medium to large-pebble gravel: clast supported; sandy matrix; chaotic structure; erosional lower contact.

Section 8929D (Section D)

Location: This section was measured on the east (main) highwall in the active part of the open pit about 30 metres south of Section C (Figure 30).

Unit	Height above base (m)	Description:
9	8.0 - 15.0	Diamicton: matrix supported; gradational lower contact.
8	6.0 - 8.0	Pebbly sand: gradational lower contact.
7	4.0 - 6.0	Fine and medium sand: very well sorted; beds are 1-10 centimetres thick, traceable for several metres, mostly massive and normally graded; thicker sand beds may show internal laminations; beds dip at 24° to the northwest (340°).
6	3.7 - 4.0	Small to large-pebble gravel: poorly sorted, massive; clasts up to small cobbles; unit dips at 24° toward the northwest (340°); sharp upper and lower contacts that are usually conformable with the sand beds; lower contact locally scoured.
5	2.7 - 3.7	Fine and medium sand: very well sorted; beds dip at 24° to the northwest (340°); beds are 1-10 centimetres thick, traceable for several metres, mostly massive and normally graded; some lenses have scoured bases, 2 centimetres deep and 20 centimetres wide; some angular inclusions of sandy pebble gravel up to 10 centimetres in diameter; lower contact is erosional.
4	2.4 - 2.7	Small to large-pebble gravel: poorly sorted, massive; clasts up to small cobbles; beds dip up to 17° toward the northeast (30°); sharp upper and lower contacts that are usually conformable with the sand beds locally have scoured bases.
3	1.5 - 2.4	Fine and medium sand: very well sorted; beds are 1-10 centimetres thick, traceable for several metres, mostly massive and normally graded; some lenses have scoured bases, 2 centimetres deep and 20 centimetres wide; some angular inclusions of sandy pebble gravel up to 10 centimetres diameter; beds dip up to 17° to the northeast (30°).
2	1.3 - 1.5	Small to large-pebble gravel: poorly sorted, massive; base of the gravels is often marked by clay injection structures and irregularly oriented sand blocks sitting unconformably on the underlying sands; clasts up to small cobbles; beds dip at 10-15° toward the northeast (030°); sharp upper and lower contacts that are usually conformable with the sand beds locally have scoured bases.
1	0 - 1.3	Fine and medium sand: very well sorted; beds dip at 10° to the northeast (030°); beds are 1-10 centimetres thick, traceable for several metres, mostly massive and normally graded; thicker sand beds may show internal laminations, usually wavy and parallel with minor trough crosslaminations

and low-angle climbing ripples; some lenses have scoured bases, 2 centimetres deep and 20 centimetres wide; some angular inclusions of sandy pebble gravel up to 10 centimetres diameter; lower contact covered.

Section 8929E (Section E)

Location: This section was measured on the east (main) highwall in the active part of the open pit about 25 metres south of Section D (Figure 30).

Unit	Height above base (m)	Description:
7	8.5 - 14.5	Diamicton: matrix supported; massive; gradational lower contact.
6	5.5 - 8.5	Diamicton: matrix supported; grey; poorly sorted, appears to be locally better sorted; cobbles and boulders abundant; gradational lower contact.
5	4.5 - 5.5	Cobble gravel: poorly sorted; clasts up to small boulders; moderate imbrication; abundant flat-lying blades and discs; crude subhorizontal stratification; upper contact grades into coarse diamicton; beds dip 25° to the north; erosional, subhorizontal lower contact.
4	1.5 - 4.5	Small to large-pebble gravel: clasts up to cobble size; poorly sorted; no obvious structures; beds dip 25° to the north; lower contact is sharp and planar.
3	0.9 - 1.5	Medium to coarse sands, fining upward to silts: thin pebble lag at the base, fines upward into medium and coarse-grained planar stratified sands, trough crossbedded medium sands and capped by horizontally bedded fine sands and silts at the top; unit shows normal faulting, some load and flame structures; beds dip 25° to the north; lower contact is erosional.
2	0.5 - 0.9	Medium sands, fining upward to silts: thin pebble lag at the base, fines upward into planar stratified medium with coarse sands, trough crossbedded medium sands and capped by horizontally bedded fine sands and silts at the top; beds dip 25° to the north; lower contact is sharp and planar.
1	0 - 0.5	Sands and gravels: poorly sorted; clasts up to large pebbles; crude inclined bedding; sandy beds alternate from fine to medium sands; beds dip 25° to the north; lower contact is covered.

Section 8929F (Section F)

Location: This section was measured at the north end of the east (main) highwall about 30 metres south of Section E (along the east side of a temporary mine road leading up to the old hydraulic pit south of the mine, Figure 30).

Unit	Height above base (m)	Description:
6	4.7 - 6.0+	Diamicton: matrix supported; massive; inaccessible; lower contact gradational.
5	4.4 - 4.7	Pebble to cobble gravel to diamicton: poorly sorted; subhorizontal bedding; unit occurs as irregular lenses and pods; inaccessible; lower contact gradational.
4	3.7 - 4.4	Silty diamicton interbedded with sandy silts: diamicton: massive, matrix supported, mainly with small to medium pebbles, few large pebbles or cobbles and a silty matrix; diamicton sample 8908; sandy silt beds: horizontally laminated, laterally traceable for ~3 metres, with few pebbles and some fine sand layers, and locally with linear markings trending ~160° (possibly shear structures from over-riding ice); diamicton sample 8909; lower contact sharp and planar to gently undulating.
3	1.1 - 3.7	Sandy gravel to gravelly diamicton: clast supported; poorly sorted; crude planar stratification marked by cobble to small-boulder concentrations at the base of some beds resulting in a crude normal grading; clasts lie subhorizontal to horizontal and are weakly imbricated; the lowest bed has an inversely graded basal layer - a well-defined lower contact marked by ~3 centimetres of pebble gravel overlain by cobbles grading up into pebble gravel; the base of bed 2 is marked by a scattered cobble concentration grading up into a pebble gravel; bed 3 is a granule to small-pebble gravel with a coarse, moderately well sorted, openwork, coarse-pebble bed at its base; clasts up to small cobbles; moderately well imbricated; matrix coarse sands, minor silts, clays, and fine to medium sands; irregularly laminated silts and clays coat some large clasts with thicker coatings to the north.
2	0.5 - 1.1	Diamicton: matrix to clast supported, crude subhorizontal stratification defined by subhorizontal phyllite clasts; horizontal to wavy laminated, well-sorted, fine sand lenses (>50 centimetres wide and ~10 centimetres thick), tabular to trough shaped; sands are locally interbedded with dark silt; unsorted, ~50-80% small to large pebbles, rounded and subrounded; up to 50% locally derived schist and phyllite clasts of Unit 1, randomly oriented, softer clasts are folded; matrix is a sandy silt with abundant mica; some altered fine-grained mafic clasts; lower contact sharp and dips 11°-16° to the north (010°) with the dip increasing northward. Unit thickens to greater than 2 metres to the north where the lower contact is covered. Diamicton sample 8907. Pebble fabric 892904.
1	0 - 0.5	Micaceous (muscovite, kaolinite, sericite, talc) phyllite: strongly altered; strongly foliated; dips 65° towards 065°; minor, white, discordant quartz veins dipping 80° towards 245°, 1-2 millimetres thick usually within silicified zones 1-10 centimetres thick, up to 1 metre long and consisting of massive, hard (~5), rusty brown quartz; quartz veins 1-5 centimetres thick and up to 10 centimetres long are locally present and have limonite patches throughout; lower contact covered. Samples 8902

(talc-rich beds 2-10 centimetres thick), 8903 (brown, kaolinite-muscovite bed 10-50 centimetres thick), 8904 (silicified zone 10-50 centimetres thick), 8905 (discordant quartz vein 1-2 centimetres thick) and 8906 (quartz in a nodular vein).

SITE 30 - GROUSE CREEK

Owner/operator: Angus and Stan Uruski
NTS: 93H/3 Spectacle Lakes
Latitude & Longitude: 53°04'N, 121°25'W
UTM: 5878700 m N, 605400 m E
Year of property visit: 1990

Site Description:

The section is an excellent exposure of gravels on the north side of lower Grouse Creek. A bedrock canyon occurs upstream from the measured section which is located at the lower end of an old hydraulic pit.

Section 9030

Location: This section is located on the north bank of lower Grouse Creek about a kilometre west of the confluence of Antler and Grouse creeks.

Unit	Height above base (m)	Description:
11	19.0 - 23.0	Pebble gravel: clast supported; poorly sorted; gravel grades upwards into matrix-supported diamicton.
10	13.0 - 19.0	Pebble to cobble gravel: large-scale planar crossbedding; beds dip uniformly to the southeast; lower contact covered.
9	7.0 - 13.0	Covered.
8	6.4 - 7.0	Small-pebble gravel: horizontally bedded; imbricated; lower contact clear and planar.
7	6.0 - 6.4	Medium to coarse sand and granule gravel: horizontally bedded; imbricated; minor small-pebble beds; lower contact clear and planar.
6	5.75 - 6.0	Small to large-pebble gravel: imbricated; poorly sorted; lower contact clear and planar.
5	5.5 - 5.75	Medium to coarse sand: horizontally laminated; lower contact clear and planar.
4	2.9 - 5.5	Sandy medium-pebble gravel with minor interbeds of medium to coarse sand: planar cross-stratified; thinly bedded; moderately sorted; lower contact clear and planar.
3	2.7 - 2.9	Coarse sand: trough-shaped lens; lower contact gradational.
2	1.9 - 2.7	Small to medium-pebble gravel interbedded with small-cobble gravel: horizontally bedded; well imbricated with paleoflow similar to Unit 2; lower contact clear and planar.
1	0 - 1.9	Large-pebble gravel: horizontally stratified; well imbricated with paleoflow to the southeast, parallel to the modern creek; mostly disc and blade-shaped clasts; moderately to well sorted; lower contact at river level.
	Bedrock:	Phyllite: some folded quartz veins; nearly vertical foliation; exposed on the south side of the creek, opposite the section.

SITE 31 - CUNNINGHAM CREEK

Owner/operator: Ralph MacPherson
NTS: 93A/14 Cariboo Lake
Latitude & Longitude: 52°58'N, 121°22'W
UTM: 5868200 m N, 610400 m E
Year of property visit: 1990

Site Description:

This property is located on the west side of Cunningham Creek approximately 20 metres above river level. The area is well known for its gold production and historically supported as many as 300 miners at one time. The site currently supports a small open-pit mine. No exposures of the auriferous sediments were available for description at the time of the property visit.

LATE WISCONSINAN (GLACIAL AND GLACIOFLUVIAL) PLACERS - (LOCATIONS 32 TO 39)

SITE 32 - COULTER CREEK

Old hydraulic pit
NTS: 93H/4 Wells
Latitude & Longitude: 53°06'N, 121°40'W
UTM: 5884000 m N, 589200 m E
Year of property visit: 1990

Site Description:

Coulter Creek is a small tributary of Slough Creek and flows into it from the north. This property was inactive when visited but some equipment was still on the site including a large processing plant. The measured section is a poorly exposed highwall in the old hydraulic pit that has been mined by heavy equipment in recent years.

Section 9032

Unit	Height above base (m)	Description:
8	18.0 - 21.0	Diamicton: massive to crudely stratified; matrix supported; very poorly sorted; sandy matrix; lower contact gradational.
7	14.0 - 18.0	Sandy gravel: crude horizontal stratification; some diamicton interbeds; poorly sorted; lower contact gradational.
6	12.0 - 14.0	Sandy pebble diamicton: massive; very poorly sorted; matrix supported; lower contact gradational.
5	10.0 - 12.0	Fine sand: horizontally bedded; beds exhibit trough crosslaminae 2-10 centimetres thick; lower contact is conformable, unit is gradational with underlying diamicton and gravel units.
4	6.0 - 10.0	Silty sand diamicton: massive; poorly sorted; matrix supported; unit grades laterally into coarse gravel similar to Unit 3; clasts are up to small boulder size; abundant striated clasts; poorly exposed; unit is recessive; lower contact is sharp and planar.
3	6.0 - 8.0	Large-cobble to boulder gravel: clast supported; sand matrix and coarser; poorly sorted; unit forms a plano-convex lens, up to 2 metres thick and 10 metres wide; (might be a subglacial tunnel deposit); sharp lower contact.
2	4.0 - 6.0	Sandy pebble gravel: grades from matrix supported to clast supported; occasional small cobbles; clasts are subangular to subrounded; poorly to very poorly sorted, almost a diamicton; compact; oxidized, light brown; lower contact is undulatory and sharp.
1	0 - 4.0	Fine sand and silt: some primary laminations but most of unit is strongly deformed with shear structures and faults; unit is laterally interbedded with poorly sorted sandy pebble gravel similar to Unit 2; lower contact covered.

SITE 33 - MAUDE CREEK

Owner/operator: Ed Darvill
NTS: 93H/3 Spectacle Lakes
Latitude & Longitude: 53°05'N, 121°27'W
UTM: 5879300 m N, 604300 m E
Year of property visit: 1990

Site Description:

This property is located on a series of broad benches on the south side of Pleasant Valley Creek near the mouth of Maude Creek. Most of the benches have been tested, with current mining activity on the highest bench.

Section 9033

Location: This section was excavated into a high bench on the west side of Maude Creek. Figure 31A is a stratigraphic column of this section.

Unit	Height above base (m)	Description:
4	6.2 - 6.5	Peat: black; well decomposed; unit thickness varies from 0-30 centimetres; lower contact interbedded.

3	5.5 - 6.2	Silt: interbedded with silty diamicton (Unit 2) and peat (Unit 4); iron oxides with some manganese staining; results reported from two assays were 240 - 310 grams per tonne (7 and 9 oz per ton, believed to be fine gold); lower contact interbedded.
2	2.3 - 5.5	Silty diamicton: locally abundant angular shale and schist clasts; some beds contain greater numbers of well-rounded clasts; flat clasts dip to the south (upslope); clasts mainly medium pebbles; total clast content up to 30%; matrix is a uniform sandy silt with crude bedding; some lenses of moderately sorted granular gravel; numerous ironstone inclusions; lower contact dips to the south.
1	0 - 2.3	Silty sand grey diamicton: massive; matrix supported; contains some gold; abundant pyrite and angular vein quartz clasts; some striated and erratic clasts; very compact and hard. In places a thin (50 centimetre) gold-bearing gravel overlies this diamicton.
	Bedrock:	Muscovite-biotite schist with oxidized pyrite, numerous weathered calcite veins and vertical foliation. Bedrock sample 9011.

SITE 34 - CUNNINGHAM CREEK

Owner/operator: Gerard and Betsy Van Halderen
NTS: 93A/14 Cariboo Lake
Latitude & Longitude: 52°59′N, 121°22′W
UTM: 5871000 m N, 610000 m E
Year of property visits: 1989, 1990

Site Description:

This open-pit mine is located on the east side of Cunningham Creek just upstream from its confluence with Cunningham Pass Creek. Some underground mining and exploration has been conducted in the area in the past.

Section 8934

Location: This section is a south-facing highwall located at the north end of the mine.

Unit	Height above base (m)	Description:
2	2.0 - 2.8	Diamicton: matrix supported; clasts mostly large and medium pebbles (~40%), cobbles and boulders common (~10%); clasts are mainly quartzite, limestone, schist, pyritized phyllite and siltstone, minor gneiss; boulders are mainly quartzite (60%) limestone (30%) and vein quartz (10%); clasts are commonly striated (~20-30%); subhorizontal irregular fracturing (2-20 centimetres spacing); matrix is a silty loam; long axes of elongated clasts generally parallel the valley orientation (000° to 005°); lower contact is gradational. Diamicton sample 8958 taken at 2.2 metres.
1	0 - 2.0	Sandy medium-pebble gravel and diamicton: massive except for very weak discontinuous subhorizontal bedding characterized by zones of variable sorting and colour changes; very poor to poor sorting with minor moderately sorted lenses; clast to matrix supported; some silty lenses a few centimetres thick and about 1 metre wide and some fine sandy laminae 2 millimetres thick and 10 centimetres wide; total clast content is about 50%; mainly a medium sand matrix with little or no silt and clay; clasts range in size from granules to small cobbles but most are small to medium pebbles; cobbles are rare and less than 10% of clasts are large pebbles; clasts are subangular to rounded, some are striated (about 5%); blades tend to lie flat; lower contact of this unit is gradational with a very hard and compact diamicton restricting deeper mining. Diamicton sample 8957 taken at 0.6 metre.
	Bedrock:	Quartzite to gneissic quartzite: grey-purple to pale red (oxidized); prominent east-trending, vertical quartz veins, 5 to 25 centimetres thick are abundant; foliation is irregular but generally dips to the northwest (300-350°) up to 20°; northwest-trending fractures; no evidence of striations or glacial markings; bedrock outcrops approximately 30 metres south of the section where the surface dips 15-20° to the north.

Section 9034E (East Section)

Location: This section is a north-facing highwall located in an active open pit at the north end of the mine, about 40 metres northeast (020°) of Section 8934.

Unit	Height above base (m)	Description:
5	1.9 - 2.3	Silt grading upward into a silty diamicton: diamicton massive; matrix supported; poorly exposed; lower contact gradational.
4	1.6 - 1.9	Diamicton: matrix supported; silty matrix; clasts up to small-cobble size; some striated clasts; shear surfaces with slickensides trending about 120°, slickenside orientation 903418; moderately compact; pebble fabric 903417; unit contains a trough-shaped, very well sorted, fine sand lens (10

		centimetres thick and 50 centimetres wide with sharp lower and upper contacts) near the top; lower contact sharp and dips up to 25° to the west.
3	1.2 - 1.6	Granular gravel grading upward into a small to medium-pebble gravel: moderately to well sorted; abundant black shale and quartz gneiss clasts, some quartz; mostly angular to subangular; lower contact gradational.
2	1.0 - 1.2	Fine sand: very well sorted; lower contact covered.
1	0 - 1.0	Covered.

Section 9034C (Central Section)

Location: This section is 5 metres west (290°) of Section 9034E on the same highwall.

Unit	Height above base (m)	Description:
5	1.2 - 2.0	Diamicton: massive; matrix supported; sandy matrix, moderately compact, 30-40% clasts; slightly calcareous; lower contact is clear and dips steeply (50°) to the west.
4	0.9 - 1.2	Fine sand: massive; very well sorted; unit forms a lens about 2 metres wide; lower contact is clear and dips steeply (50°) to the west.
3	0.5 - 0.9	Coarse sand grading upward into medium-pebble gravel: gravel moderately sorted and similar to Unit 3 in the East section; lower contact is clear and dips steeply (50°) to the west.
2	0.4 - 0.5	Fine sand: massive; very well sorted; lower contact is gradational and dips steeply (50°) to the west.
1	0 - 0.4	Silty sand diamicton: massive; matrix supported; compact; lower contact covered.

Section 9034CW (Central-west Section)

Location: This section is 3 metres west (290°) of Section 9034C on the same highwall.

Unit	Height above base (m)	Description:
5	2.2 - 2.4	Granule to small pebble gravel: massive; poorly exposed; lower contact gradational.
4	1.7 - 2.2	Medium to large-pebble gravel: well sorted; massive; poorly exposed; lower contact gradational.
3	1.0 - 1.7	Granular coarse sand: massive; lower contact is clear and dips steeply (40°) to the west.
2	0.5 - 1.0	Diamicton: massive; matrix supported; sandy matrix, moderately compact, 30-40% clasts; slightly calcareous; lower contact is clear and dips steeply (40°) to the west.
1	0 - 0.5	Covered.

Section 9034W (West Section)

Location: This section is 4 metres west (250°) of Section 9034CW on the same highwall.

Unit	Height above base	Description:
3	2.1 - 2.35	Sand and silt: horizontal bedding; lower contact subhorizontal.
2	1.0 - 2.1	Granular gravel: massive; poorly exposed; lower contact covered.
1	0 - 1.0	Covered

Section 9034S (South Section)

Location: This section is 4 metres west (250°) of Section 9034CW on the same highwall.

Unit	Height above base (m)	Description:
6	2.55 - 3.35	Diamicton: massive; matrix supported; sandy matrix; compact; 20-30% clasts, mainly medium to large pebbles; rare cobbles; unit has thin sandy lenses throughout, up to 0.5 centimetre thick and 10 centimetres long; lower contact gradational.
5	2.45 - 2.55	Small-pebble diamicton: massive except for thin silt and fine sand beds with wavy laminae; matrix supported; silty matrix; lower contact gradational.
4	2.15 - 2.45	Pebble to cobble sandy gravel: poorly sorted; lower contact subhorizontal.
3	2.05 - 2.15	Small to medium-pebble gravel: massive; poorly exposed; unit is the south edge of a small lens pinching out to the south; lower contact clear and dips to the north.
2	1.25 - 2.05	Fine to medium sand; crude horizontal stratification; very well sorted; lower contact covered.
1	0 - 1.25	Covered.

Section 9034D

Location: This section was measured at an exposure below the level of Section 9034C on the same highwall.

Unit	Height above base (m)	Description:
2	1.0 - 2.0	Diamicton: massive; matrix supported; clasts mainly medium pebbles; lower contact gradational.
1	0 - 1.0	Large-pebble gravel: trough crossbedded; clast supported; well imbricated; poorly sorted; abundant angular local clasts; unit contains a small pebbly sand lens about 25 centimetres thick with internal horizontal laminae; lower contact covered.

SITE 35 - SNOWSHOE CREEK

Owner/operator: Yanks Peak Resources Ltd.
NTS: 93A/14
Latitude & Longitude: 52°50′N, 120°28′W
UTM: 5853800 m N, 603100 m E
Year of property visit: 1989

Site Description:

This open-pit mine site is located on the lower slope of Yanks Peak on the southwest side of the mountain between French Snowshoe and Snowshoe creeks. The mine was inactive at the time of the property visit.

Section 8935

Location: This section was located in test pit at the east side of the mine area.

Unit	Height above base (m)	Description:
3	4.0 - 14.0	Diamicton: matrix supported; silty sand matrix; up to 10 metres thick; total gravel content is about 50%; mainly pebbles and about 10% cobbles; rare boulders up to 1.5 metres diameter; clasts are subrounded to angular and commonly striated; weakly developed stratification is locally evident as a result of cobble concentrations.
2	1.0 - 4.0	Interstratified moderately to well sorted sand, poorly sorted pebbly sand and gravel, and diamicton: beds dip downslope 5°-10°; minor horizontally laminated, granular, silty clay beds; unit thickens to 12 metres at one locality but in most areas is absent and diamicton of Unit 3 directly overlies bedrock.
1	0 - 1.0	Bedrock: micaceous quartzite and schist.

SITE 36 - GOLD CREEK

Owner/operator: Walter Nemanishen and Walter Zolinski
NTS: 93G/8
Latitude & Longitude: 53°21′N, 122°05′W
UTM: 5911400 m N, 560200 m E
Year of property visit: 1990

Site Description:

The Gold Creek property is located near Hay Lake in the Ahbau Creek valley. Section 9036A is near the apex of a small alluvial fan-delta built out into into the Ahbau Creek valley at the south end of Hay Lake. Section 9036B (Figure 31C) is near the south end of a small northerly trending meltwater channel that joins Gold Creek just upslope from the fan. The measured section was in a test pit in the bottom of the meltwater channel in a broad, forested flat ~100 metres off the forestry road. Activity at this site has been restricted mainly to a systematic testing program.

Section 9036A

Location: Section 9036A is near the apex of a small alluvial fan-delta built into Hay Lake by Gold Creek (at the end of a small road behind the residence).

Unit	Height above base (m)	Description:
9	8.5 - 10.0	Sandy small-pebble to large-cobble gravel with sand interbeds: beds 10-50 centimetres thick; poorly sorted; crudely imbricated suggesting flow towards 180°; sand lenses and small scour-fill structures

		10-20 centimetres thick and 1-2 metres wide are common; some small-pebble openwork clast clusters; scour structures are infilled with well-sorted coarse sand to medium-pebble beds; sand lenses exhibit low-angle trough crossbeds and horizontal laminae; minor iron oxide staining; this gravel contains porphyritic quartz monzonite(?) erratics with zoned potassium feldspar phenocrysts from the Maxwell Creek area to the north.
8	8.0 - 8.5	Sandy cobble gravel: poorly sorted; crudely imbricated; some small lenses of fine-laminated sand and small openwork granule to small-pebble gravel; lower contact erosional and dips to the south-southeast (160°).
7	7.25 - 8.0	Small-pebble gravel and granular coarse sands: horizontally bedded; well sorted; unit infills a broad trough and grades to the south into a coarser pebble gravel; lower contact dips up to 15° towards 070°; minor iron oxide staining.
6	6.25 - 7.25	Small-pebble to large-cobble gravel: massive to inversely graded; some cobble-clast clusters especially near the base of the unit; matrix of medium sand and coarser; clasts mostly subangular to subrounded; clasts mainly green, fine-grained extrusives, weathered schists, gneiss, quartz and sandstone; unit thickens to the north; lower contact gradational.
5	6.0 - 6.25	Sandy medium-pebble gravel: matrix filled with fine sand and coarser; very crude horizontal bedding; poorly sorted; lower contact gradational.
4	5.5 - 6.0	Medium to coarse micaceous sand: horizontal stratification; thinly bedded; some crosslaminated sand beds; scattered small to medium pebbles in some beds in the upper 25 centimetres; lower contact erosional.
3	5.25 - 5.5	Medium to coarse sand and granular gravel: planar crossbedding; well sorted; beds dip to the south-southwest (215°); lower contact gradational.
2	2.0 - 5.25	Coarse gravel: poorly exposed; large greenstone cobbles and boulders at the top of the unit are infilled with sand of the overlying unit. This gravel acts as an aquifer that feeds a small spring and supplies good quality drinking water.
1	0 - 2.0	Small-pebble to large-cobble gravel: crude horizontal stratification, poorly sorted; some trough-shaped, moderately sorted, horizontally stratified, coarse-sand lenses (up to 25 centimetres thick and 2 metres wide); unit is inversely graded with bouldery gravel in the upper 50 centimetres and granular to large-pebble gravel in the lower metre; abundant iron oxide staining; lower contact covered.

Section 9036B

Location:

Section 9036B is near the head of a small glacial meltwater channel that joins with a larger system to the north.

Unit	Height above base (m)	Description:
6	9.3 - 10.0	Fine to medium sand: mainly massive but locally some crude horizontal bedding, mottled red and brown, lower contact gradational.
5	8.5 - 9.3	Crudely imbricated gravel: medium-pebble to large-cobble bed at the base; some openwork trough-shaped lenses of small-pebble gravel; some moderately to poorly sorted large-pebble to small-cobble beds with fine sand to granule matrix; coarser beds contain intraclasts of laminated silt; unit is well oxidized; reported gold contents in this unit are up to 1.5 to 3 grams per tonne; pebble imbrication indicates paleoflow to the north (345°); lower contact is sharp and undulatory (erosional and probably scoured). Pebble lithologies (medium to large pebbles), biotite-muscovite schist 20%, green mafic extrusive 28%, coarse diorite/pyroxenite? (mafic intrusive) 16%, black mafic extrusive 8%, granite 8%, vein quartz 4%, quartz-biotite gneiss 4%, quartzite 4%, chert 4%, phyllite 4%.
4	7.9 - 8.5	Silt and clay: horizontally laminated; some dropstones; minor granule to small-pebble beds; laterally (20 metres away) this unit has large boulders and is up to 2 metres thick; near the valley walls silt of this unit is up to 2 metres thick and is underlain by at least 3 metres of barren granule to medium-pebble gravel; lower contact is sharp and planar.
3	7.5 - 7.9	Granular gravel: well sorted; poorly exposed.
2	5.0 - 7.5	Granular to medium-pebble gravel: well sorted with little or no matrix; uncemented; poorly exposed; lithologically similar to Unit 5 gravel but finer grained.
1	0 - 5.0	Granular to medium-pebble gravel: not presently exposed; these lower gravels are locally well cemented with iron and manganese oxides; depth to bedrock unknown. Pebble lithology (of small to medium pebbles from backhoe pits at depths of 8-10 metres): green fine-grained extrusive 44%, muscovite schist 16%, quartzite 12%, chlorite schist 8%, black fine-grained extrusive 8%, diorite 8%, granite (strongly weathered) 4%.

SITE 37 - TREGILLUS LAKE

Owner/operator: Dale Pauls
NTS: 93H/4 Wells
Latitude & Longitude: 52°08'N, 121°56'W
UTM: 5887600 m N, 571300 m E
Year of property visit: 1990

Site Description:

This property is located along the east shore of Tregillus Lake in the Beaver Pass valley. The mine site is on a broad flat part of the valley with occasional bedrock highs. Surface gravels have been mined in shallow (less than 5 metres deep) open pits throughout the area.

Section 9037 (Langford Mine Section)

Location: This section was measured on the east side of the mine site at the edge of the mined area (Figure 31D).

Unit	Height above base (m)	Description:
5	1.5 - 2.0	Cobble to boulder gravel: massive; poorly sorted; matrix supported; pebbly silty sand matrix; occasional large angular boulders on or near the upper surface; boulders are gneiss or schist, gneisses have thick layers of quartz and the schists are garnetiferous, both are local; some quartz gneisses, vein quartz, metasandstone and minor green diorite; Bf soil horizon development; organics (rootlets) throughout; lower contact gradational.
4	1.0 - 1.5	Cobble gravel: clast supported; massive; matrix filled, matrix of fine sand and coarser, little silt or clay; poorly sorted, clasts are subangular to rounded; moderate imbrication; most platy clasts flat lying or imbricated with paleoflow towards the northeast; unit fines upward, coarsest clasts toward the base; some diamicton and clay intraclasts; the thickness of Units 4 and 5 combined varies from 0.5 to 2.0 metres; limonite stained; lower contact is gradational, horizontal.
3	0.5 - 1.0	Large-pebble to small-cobble gravel: some beds of small to medium-pebble gravel; lenses of small to medium pebbles; mostly openwork; very little sand matrix, mostly granules and coarser; subrounded to rounded clasts; some intraclasts of small pebbly fine sand; unit coarsens upwards; lower contact is poorly exposed, mainly gradational but locally erosional.
2	0.2 - 0.5	Small-pebble gravel: clast supported; crude horizontal bedding; clasts are subrounded to rounded; pebble lithologies, 25% vein quartz, 25% quartz gneiss, 20% schist, 15% gneiss, 10% quartzite, 5% phyllite; matrix of coarse sand and granules; mainly openwork but some matrix-filled beds; some iron oxide cemented gravels; lower contact gradational.
1	0 - 0.2	Large-pebble gravel: openwork; moderately sorted; minor matrix; subrounded to rounded clasts; lower contact covered.

SITE 38 - PINUS CREEK

Owner/operator: Tom Hatton
NTS: 93H/4 Wells
Latitude & Longitude: 53°09'N, 121°32'W
UTM: 5888500 m N, 598800 m E
Year of property visit: 1989

Site Description:

The mine site is located at the confluence of Shepherd and Pinus creeks and an unnamed meltwater channel running parallel to, and just east of, Pinus Creek. Shepherd Creek runs through a narrow bedrock-floored meltwater channel before joining Pinus Creek. The property supports a large open-pit mining operation removing the upper few metres of the surficial sediments. No good exposures were available for description.

SITE 39 - CARIBOO RIVER

Owner/operator: Lloyd Tattersall (Big Valley Resources Ltd.)
NTS: 93 A/12 Hydraulic
Latitude & Longitude: 52°39′ N, 121°30′ W
UTM: 5834800 m N, 600600 m E
Year of property visit: 1990

Site Description:

This site is located on a series of terraces along the Cariboo River directly downstream from its confluence with Spanish Creek. A number of cable-tool drill holes, trenches and test pits have been excavated in the area. Detailed records of gold concentration, nugget shape and grain-size distribution at different stratigraphic levels were maintained during evaluation of the property.

Section 9039A (Terrace Section)

Location: This is a composite section of an exposure on the south side of the Cariboo River (Units 1 to 5) and a road-cut exposure in a terrace at the top of the section (Units 6 to 10). The base of the exposure is approximately 20 metres above river level. Bedrock outcrops along the river and is separated from the base of the section by a 10-metre covered interval.

Unit	Height above base (m)	Description:
10	22.75 - 29.0	Cobble to large-pebble gravel: poorly exposed; reddish coloured; lower contact sharp and unconformable (subhorizontal to slightly scoured). The upper surface of this unit forms a flat bench (terrace).
9	22.25-22.75	Silt and clay at base coarsening upward to fine sand: horizontal bedding; with low-angle small-scale trough crossbeds in the upper sandy horizons; lower contact gradational.
8	22.0 - 22.25	Interbedded silt and clay: horizontally laminated; minor coarse sand and silty diamicton beds; lower contact clear and horizontal.
7	21.5 - 22.0	Diamicton: massive; matrix supported; compact; some striated clasts; matrix finer than Unit 6 (sandy silt to silt with some clay); lower contact sharp.
6	21.0 - 21.5	Diamicton: massive; matrix supported; compact; some striated clasts; matrix silty sand to sand; lower contact covered.
5	20.0 - 21.0	Covered, probably gravel similar to Unit 4.
4	17.5 - 20.0	Cobble to boulder gravel fining upward into large-pebble gravel: boulders are concentrated at the base; moderately to well sorted; poorly exposed; clasts are rounded to well rounded (better than below); lower contact erosional.
3	16.25 - 17.5	Silty sandy cobble gravel: almost matrix supported; poorly sorted; clasts up to to boulder size; lower contact gradational.
2	10.25-16.25	Large-pebble to cobble gravel: clast supported; well imbricated; horizontally bedded; mainly matrix filled; poorly sorted; matrix of silt and coarser; clast roundness and lithology similar to Unit 1 below; median grain size of beds as follows:
	15.25 - 16.25	Medium to large-pebble gravel
	14.25 - 15.25	Large-cobble gravel
	12.25 - 14.25	Large-pebble to cobble gravel
	11.5 - 12.5	Large-pebble gravel fining upward into a small-pebble gravel
	10.25 - 11.5	Cobble gravel: lower contact scoured; thickens to 2 metres over 4 metres distance.
1	0 - 10.25	Small to large-pebble gravel: clast supported; well imbricated; horizontally bedded; some stratified sand beds; moderately to well sorted; clasts rounded to well rounded, some subangular to subrounded; mainly matrix filled; matrix of fine sand and coarser; pebble lithologies, 20% sandy quartzite, 16% schist, 12% quartzite, 12% vein quartz, 8% felsic igneous, 8% phyllite, 8% diorite, 8% limestone, 4% gneiss, 4% argillite; median grain size of beds as follows:
	8.25 - 10.25	Large-pebble gravel: gradational lower contact
	6.25 - 8.25	Medium to large-pebble gravel: scoured lower contact; cobble lag at base
	4.25 - 6.25	Large-pebble gravel: scoured lower contact; bed is lens shaped
	3.0 - 4.25	Medium to large-pebble gravel
	2.5 - 3.0	Pebbly sand; bed forms a trough-shaped lens
	2.0 - 2.5	Medium to large-pebble gravel
	1.0 - 2.0	Small-pebble gravel with interbeds of medium to large-pebble gravel: some nearly openwork, trough-shaped small-pebble lenses.
	0 - 1.0	Large-pebble gravel: lower contact covered.

Section 9039B (Cabin Terrace Section)

Location: This section is located on the highest terrace in the area. The section was measured in a large test pit at the west end of a clear-cut area on the terrace. The terrace slopes about 10° to the south of the pit and rises steeply to the north, onto the valley wall.

Unit	Height above base (m)	Description:
11	6.4 - 7.7	Silt: some clay; coarsens upwards almost to a very fine sand; strongly deformed laminae; unit forms the top unit of the terrace.
10	6.2 - 6.4	Medium-pebble gravel with some large pebbles: unit forms a trough-shaped lens; lithologically varied; clasts are subangular to well rounded; lower contact scoured (erosional).
9	5.7 - 6.2	Clay and silt: silt dominates; some thin, fine sandy laminae; horizontally laminated with a slight dip of beds (1-2°) toward the northeast (035°) as in underlying units (7 and 8); dark brown-grey colour; lower contact gradational.
8	5.3 - 5.7	Fine sand: horizontally laminated: laminae are less than 0.5 centimetre thick; some contorted and deformed laminae and crosslaminae; beds dip slightly (1-2°) toward the northeast (035°); yellowish colour; abundant rootlets; lower contact near horizontal.
7	5.0 - 5.3	Clay and silt: mostly clay, some silt; fine rhythmic laminae; some contorted bedding and some bifurcated laminae; possible flow folding; beds dip slightly (1-2°) toward the northeast (035°); indurated; greyish colour when dry; breaks into conchoidal blocks; lower contact conformable.
6	4.5 - 5.0	Cobble to boulder gravel: grades up into a small to medium-pebble gravel; massive; clast supported; matrix filled to openwork; boulders at the base; very poorly sorted; sorting better towards the top; the base of this unit locally has a thin silt and clay bed about 10 centimetres thick and 1-2 metres wide; clasts are subrounded to rounded; boulders are more commonly subrounded; lower contact is erosional and sharp.
5	3.5 - 4.5	Large-pebble gravel: massive; clast supported with some matrix-supported zones; matrix filled; matrix mainly fine sand and coarser, some silt; red colour due to iron oxidation; very poorly sorted; clasts are small pebbles to cobbles; cobbles are more common towards the base.
4	3.25 - 3.5	Sand: unit is a wedge-shaped lens that thins to the northeast and thickens to the southwest; lower contact clear.
3	2.75 - 3.25	Small-pebbly gravel: thinly bedded; beds 5-10 centimetres thick; matrix filled; clast supported; lower contact clear and horizontal.
2	2.5 - 2.75	Granular sand: some small-pebble lenses: unit forms a wedge-shaped lens that thickens to the southwest and pinches out to the northeast.
1	0 - 2.5	Medium to large-pebble gravel: some small-pebble beds; one cobble bed (lag?) at the top of the unit; low-angle planar crossbedding; beds dip toward the northeast; beds 10-50 centimetres thick; moderately sorted; matrix filled; clasts are subrounded to rounded; lower contact covered.

Section 9039C (Trench Section)

Location: This section was measured on the same terrace level as Section 9039B but at the east end of the clear-cut, farther south and closer to the valley wall. The described deposits were exposed in bulldozer trenches over an east-west distance of 100 metres and a north-south distance of more than 30 metres.

Unit	Height above base (m)	Description:
9	6.7 - 7.2	Interbedded small-pebble and medium to large-pebble gravel: has a reddish tinge; small-pebble beds are ~2 centimetres thick, well sorted and almost openwork (minor fine sandy matrix); clasts are subangular to subrounded; medium to large-pebble beds are 10-20 centimetres thick, matrix filled and clast supported with a matrix of fine sand; unit pinches out to the south and thickens to the north.
8	6.2 - 6.7	Fine to coarse sand with minor sandy granular to small-pebble gravel: horizontally bedded; unit thins upslope toward the south (lens shaped); lower contact is sharp and gently scoured (scours a few centimetres deep and ~50 centimetres wide); locally the lower contact has a lag pebble gravel.
7	3.9 - 6.2	Clay and silt: mostly clay with thin laminae of fine sand (less than 1 millimetre thick); unit coarsens upwards slightly, but is still dominantly clay with silt; very well laminated/bedded with strata dipping to the north; dip angles on bedding surfaces decrease up section from 10-14° at the base to 3-7° at the top; strata are 1-2 centimetres thick and contacts are marked by fine sandy partings yellow-brown in colour; internally the beds have thin laminations; some fine sandy beds with erosional lower contacts (low-angle scours) that truncate underlying beds; minor small lenses of convoluted very fine sand up to 1 centimetre thick by 5-10 centimetres wide; no clasts; unit grades to the south and east into mainly fine to medium sands with pebble-gravel interbeds and large-scale trough crossbedding; lower contact clear and planar.
6	3.85 - 3.9	Silt and fine sand: thin parallel laminae; abundant organics; oxidized (light brown colour); numerous small rootlets; lower contact clear and planar.
5	3.75 - 3.85	Silt and clay: thin interbeds of fine sand; dominantly horizontal rhythmic bedding; some internal ripple bedding/laminae and climbing ripples (all types); climbing ripples indicate a paleoflow to the

		west; some fine to medium sand beds; strata locally distorted by microfaults and convoluted bedding; some load structures and folds; unoxidized (black to grey colour); lower contact forms a sharp, undulatory surface that dips 10° to 14° to the north (020°); the undulations are due to erosional trough-shaped scours that crosscut beds in Unit 4 and are about 1 to 3 metres deep by several metres wide (8-15 metres); silt and clay of this unit fill the scours and drape high points along the contact.
4	2.75 - 3.75	Sandy large-pebble to small-cobble gravel: some boulders; chaotic to very crudely bedded; matrix filled; matrix is mostly fine to medium sand, very little coarse sand; poorly sorted; some small lenses of openwork gravel; iron and manganese stained at the base; clasts are subangular to subrounded; some angular inclusions of laminated clay and silt; some very angular clasts of local argillaceous bedrock; openwork lenses are locally more common towards the base; the unit thickness varies from 50-150 centimetres; lower contact is erosional (scoured) and dips to the north (000°) up to 20°.
3	1.25 - 2.75	Interbedded medium to coarse sand and small to medium pebbly gravel: horizontal bedding and small-scale trough crossbedding; beds are 1-10 centimetres thick; some scour-fill sequences with thin openwork pebble gravel grading upward into finer grained matrix-filled pebble gravel; most beds are matrix filled; lower contact is scoured and dips up to 25° to the north (towards the valley centre).
2	1.0 - 1.25	Diamicton interbedded with silty fine sand: diamicton similar to Unit 1; sand beds discontinuous; lower contact gradational.
1	0 - 1.0	Diamicton: massive; matrix supported; compact; very hard; sandy silt matrix; some striated clasts; clasts subangular to subrounded; mostly medium and large pebbles; lower contact covered.

POSTGLACIAL PLACERS
HIGH TO INTERMEDIATE-LEVEL TERRACE SETTINGS
(LOCATIONS 40 - 45 and 48)

SITE 40 - MAN-MADE CREEK

Ketch hydraulic pit
NTS: 93H/4 Wells
Latitude & Longitude: 53°05'N, 121°41'W
UTM: 5881500 m N, 589000 m E
Year of property visit: 1990

Site Description:

This site is located on a bench on the lower slope of Burns Mountain above the old Ketch hydraulic pit. Hydraulic operations conducted in the area in the past include the Ketch and China pits. The area has a poor water supply and Man-made Creek presumably derived its name from the fact that water was brought to the site from Burns Creek.

Section 9040

Location: This section describes a remnant highwall on the north side of the old hydraulic pit.

Unit	Height above base (m)	Description:
5	2.7 - 3.4	Large-pebble gravel: horizontally stratified; well imbricated indicating a northeasterly paleoflow; poorly to moderately sorted; sand to silty sand matrix; clasts mainly local and up to boulder size; partially cemented; red colour due to iron oxidation; lower contact clear and horizontal. Pebble fabric 904014.
4	2.6 - 2.7	Granular gravel: horizontally stratified; openwork; imbricated; lower contact clear and horizontal.
3	2.0 - 2.6	Large-pebble to medium-pebble gravel: lens-shaped unit; well imbricated; openwork; fining upwards; lower contact erosional and trough shaped. Pebble lithology sample 9002.
2	1.0 - 2.0	Small-pebble gravel: moderately well sorted; openwork; granules to medium pebbles; clasts are subangular, mostly bladed phyllite and some quartz; poorly exposed; lower contact erosional.
1	0 - 1.0	Diamicton: massive; matrix supported; sandy micaceous silt matrix; compact; subangular clasts; abundant local phyllite; clasts commonly flat lying; lower contact covered. Diamicton sample 9001. Bedrock was exposed approximately 3 metres below the base of the section.

SITE 41 - BURNS CREEK

Owner/operator: Tom Hatton
NTS: 93H/4 Wells
Latitude & Longitude: 53°05'N, 121°40'W
UTM: 5881000 m N, 589500 m E
Year of property visit: 1990

Site Description:

This open-pit mine is located on a high terrace along the south side of the Slough Creek valley and east of Burns Creek. A stratigraphic column of the terrace gravels exposed at this site are provided in Figures 33 A and 33B.

Section 9041A

Location: This section is located in the active mining area near the east bank of Burns Creek. The upper 0.25 - 0.75 metre of bedrock is mined at the site and washed with the overlying gravels.

Unit	Height above base (m)	Description:
7	3.7 - 4.7	Large-pebble to cobble gravel: chaotic; silty sand matrix; poorly sorted; possibly colluvium or old tailings; some soil development (red sandy Bf or Bm horizon development); soil development irregular (probably disturbed by colluvial processes or human activities).

6	3.2 - 3.7	Interbedded medium to large-pebble and small-pebble gravel: horizontally bedded; some weak scour structures; beds are about 10 centimetres thick; openwork; no sand or fines; moderately sorted; occasional cobbles in medium to large-pebble beds; pebble lithologies, schist 20%, quartz gneiss 24%, vein quartz 24%, gneiss 4%, metasiltstone 8%, quartzite 12%, shale 8%; these pebbles are mainly local with no distal igneous clasts observed.
5	2.8 - 3.2	Small-cobble to boulder gravel fining upward to medium and large-pebble gravel: unit is similar to the preceding (Unit 4) except it has more boulders at the base; lower contact erosional.
4	2.3 - 2.8	Small-cobble to boulder gravel fining upward to a large-pebble gravel: poorly to moderately sorted, clast supported; matrix is medium sand and coarser; lower half of unit is openwork and also limonite stained; angular intraclasts of matrix-supported, silty diamicton with striated rocks occur in the bottom half (intraclasts are about 20 centimetres in diameter); boulders up to 2 metres in diameter with some striations; gravel in the upper half of the unit is less well sorted; lower contact is horizontal and poorly exposed.
3	0.8 - 2.3	Sandy small to medium-pebble gravel interbedded with medium to large-pebble gravel: some weakly developed planar crossbedding; openwork; beds are 10-40 centimetres thick and contain some cobbles; granule to small pebble-sized clasts occur between large pebbles and cobbles; clasts are mainly vein quartz, gneiss and schist; schistose clasts are angular, others are subrounded to rounded; lower contact is poorly exposed.
2	0.6 - 0.8	Breccia: unit consists mainly of angular, broken bedrock fragments with some pebble gravels; lower contact gradational.
1	0 - 0.6	Bedrock: mica schist; weathered; oxidized; small pyrite crystals; foliation is near horizontal.

Section 9041B

Location: This section is located near the east bank of Burns Creek, approximately 50 metres northwest of Section 9041A, close to the edge of the same bench.

Unit	Height above base (m)	Description:
3	3.0 - 3.5	Diamicton: poorly exposed, colluvium
2	2.0 - 3.0	Granular to small-pebble gravel, coarsening upward into medium to large-pebble gravel: crude horizontal bedding; clasts mostly flat lying, some openwork beds at the base and some weak scour structures; towards the terrace edge (north) beds dip up to 40° to the northeast, probably due to downslope movement along edge of terrace.
1	0 - 2.0	Breccia: angular, broken bedrock boulders (gneiss and schist); crude beds dip up to 40° to the northeast; some poorly sorted silty pebble gravels between the boulders; more rounded clasts at the top of the unit; a small trough-shaped lens, about 50 centimetres thick and 2 metres wide, of poorly to moderately sorted small to medium-pebble gravel occurs in the upper half of the unit.
	Bedrock:	Mica schist and gneiss.

Section 9041C

Location: This section is located at the west end of the active mining area approximately 100 metres southwest (upslope) of Section 9041A, and 20 metres closer to Burns Creek. Figure 33A is a stratigraphic column of this section.

Unit	Height above base (m)	Description:
5	3.75 - 3.85	Organics: humic Ah horizon; scattered large boulders occur on the surface.
4	3.5 - 3.75	Large pebbly sand: scattered cobbles; matrix to clast supported; unit has a well-developed Ae horizon in the upper 10 centimetres; lower contact gradational.
3	2.5 - 3.5	Large-pebble gravels: most clasts in the small-pebble to small-cobble range with some cobbles and rare boulders; clast supported; poorly sorted; matrix filled, matrix is mainly coarse sand; patchy iron oxidation in a Bf horizon in the upper 70 centimetres.
2	1.5 - 2.5	Medium to large-pebble gravel: planar crossbedded; alternating beds of openwork medium to large-pebble gravel and beds of medium-pebble gravel with a coarse sand matrix; beds are 10-15 centimetres thick with an apparent dip direction of 100° and dip of 10-11°; clasts are subangular to rounded, some angular vein quartz (both local and distally derived clasts); occasional large boulders, subangular to subrounded, up to 1 metre size, not local; lower contact is sharp. Pebble lithologies: 22% quartz gneiss; 20% schist; 15% quartzite; 15% vein quartz; 12% gneiss; 8% metavolcanics; 4% metasediments; and 4% gabbro.
1	0 - 1.5	Bedrock: muscovite, quartz and biotite schist; some thick (gneissic) crude foliation; bedrock surface dips toward 020°; foliation dips 25° toward the north (020°); planes of weakness have similar strike and dip steeply to the north; vertical fractures strike at 065°; abundant fine sands occur along foliation and fracture surfaces in the bedrock with probable high gold content; upper contact is smooth and waterworn.

Section 9041D (East Section)

Location: This section is located in an open pit at the east end of active mining area on a slightly lower terrace level than Section 9041A and about 300 metres to the northeast.

Unit	Height above base (m)	Description:
6	3.7 - 5.0	Large-pebble gravel with some small cobbles: subangular to subrounded clasts; matrix filled with medium sand and coarser; iron oxidation in Bf horizon increases in strength towards the top of the unit and has a diffuse lower boundary; Ae horizon well developed from 470-490 centimetres; Ah horizon well developed in upper 10 centimetres; lower contact scoured, scour surface ~50 centimetres deep over 5 metres and dips to the north (010°).
5	3.25 - 3.7	Small pebbly sand: planar crossbedding; beds dip up to 20° to the south (180°); lower contact scoured and marked by a medium to large-pebble lag.
4	2.85 - 3.25	Medium to coarse sand with some granule beds: trough crossbedded; unit forms a lens about 5 metres wide; lower contact gradational.
3	2.7 - 2.85	Small pebbly sands: horizontally bedded; grades laterally to the south into trough crossbedded gravels; lower contact conformable.
2	2.0 - 2.7	Medium-pebble gravel: some small to very large pebbles and rare cobbles; good horizontal stratification; some crude planar crossbeds; moderately well imbricated indicating an easterly paleoflow; interbedded openwork and matrix-filled beds; minor oxidized patches, usually in openwork beds; clasts are subangular to subrounded; openwork beds dominate the lower half, matrix-filled beds the upper half; matrix in matrix-filled beds is fine to coarse sands; unit thickens to the north and pinches out to the south (comprising the south limb of a large trough-shaped unit); lower contact is erosional, dipping 11° to the north and is locally marked by a boulder lag.
1	0 - 2.0	Cobbly gravel: clasts are small pebbles to large cobbles with rare boulders; massive to weak horizontal stratification; clast supported; poorly sorted; matrix filled; matrix of coarse sand and coarser; clasts are subangular to subrounded, some rounded to well rounded; the top 20-40 centimetres is a limonite stained, openwork small pebbly granular lens with a few larger clasts; lower contact onto bedrock is reported to be 50-100 centimetres below the section base.

SITE 42 - CARBERRY CREEK (Quesnel River)

Owner/operator: Blue Ice mine (Borkowski and Harms)
NTS: 93A/12 Hydraulic
Latitude & Longitude: 53°37'N, 121°34'W
UTM: 5831000 m N, 597000 m E
Year of property visit: 1990

Site Description:

This site is located on a high terrace along the north side of the Quesnel River about 2 kilometres northwest of Likely. The south-flowing Carberry Creek joins the Quesnel River valley at this location and is the site of an old hydraulic mine (Excelsior pit). Current open-pit mining provides several good exposures in the area.

Section 9042A(Terrace Section)

Location: This section is located in an open pit near the centre of the terrace.

Unit	Height above base (m)	Description:
9	5.75 - 6.50	Silts: massive; several buried soil (Bf, Ae and Cca) horizons.
8	4.75 - 5.75	Pebble gravel interbedded with sands: erosional lower contact forms a trough 5 metres wide and up to 2 metres deep.
7	3.75 - 4.75	Silt, clay and sand: horizontally bedded; silt and clay beds are 1-2 centimetres thick; fine to medium sand beds are 2-10 centimetres thick; unit is laterally continuous.
6	2.75 - 3.75	Fine and medium sand: horizontally bedded; few coarse sand beds; well sorted; unit coarsens upward with some pebbly sand near the top; fine sand beds are 0.5 to 2 centimetres thick and coarser sand beds are 1-5 centimetres thick; unit forms a trough-shaped lens which conforms to the shape of the underlying unit.
5	2.25 - 2.75	Small-pebble gravel interbedded with medium to large-pebble gravel: horizontally bedded; moderately well sorted; beds are almost openwork, some are filled with a medium sand matrix; beds are 2-10 centimetres thick; unit forms a trough-shaped lens about 5 metres wide; lower contact trough shaped.
4	1.25 - 2.25	Large-cobble gravel (ranges from small pebbles to boulders): massive; matrix filled; clast supported; unit thickens laterally to as much as 2 metres; poorly sorted; boulders are up to 2 metres diameter;

		clasts mostly subrounded but vary from subangular to rounded; varied lithologies: some local conglomerates, local limestone and some quartzites, igneous and metamorphic rocks; matrix is fine sand and coarser; matrix is locally moderately sorted and exhibits crude subhorizontal bedding; lower contact is clear and undulatory.
3	1.0 - 1.25	Diamicton: massive; matrix supported; brown colour; (unit may be an oxidized zone of Unit 2); more sandy and not as compact as Unit 2 with more clasts (up to 50%) and clasts are overall slightly larger; no fissility, poorly exposed; lower contact sharp.
2	0.5 - 1.0	Diamicton: massive; matrix supported; silty sand matrix; compact and mostly small to large pebbles; clasts are subangular to subrounded; dark grey colour; some horizontal fissility; poorly exposed; lower contact irregular (infills lows in the bedrock), mostly covered.
1	0 - 0.5	Bedrock: limestone; mostly microcrystalline; massive; abundant calcite veins; breaks subconchoidally; has a water-washed upper surface; only a small knoll exposed.

Section 9042B (Excelsior Gulch Section)

Location: This section is located at the base of an exposure in the old Excelsior hydraulic mine. The Excelsior pit occurs near the head of Carberry Creek, a small tributary of the Quesnel River draining to the south from the hillside north of the terrace.

Unit	Height above base (m)	Description:
6	2.4 - 5.4	Diamicton: massive, matrix supported; silty matrix; very hard and compact; some vertical jointing; abundant striated clasts; the lower part of the unit has some crushed and fractured clasts of siltstone; laterally this unit attains a thickness of 20 metres; the outer metre (surface) of the diamicton is less compact, probably due to colluviation; lower contact is sharp/clear and planar.
5	2.2 - 2.4	Silty sandy pebble gravel: poorly sorted; clasts small to large pebbles; matrix of silt and sand; in the middle of the unit is a well sorted fine sand bed that is ~5 centimetres thick and continuous for several metres.
4	2.0 - 2.2	Medium sand: unit is lens shaped with internal trough crosslaminae; lens thickens to the north, dips to the south; well-sorted; lower contact is sharp and trough shaped.
3	0.2 - 2.0	Medium to large-pebble gravel: matrix filled with fine sand; beds mostly 5-10 centimetres thick; abundant small openwork beds; beds dip 15° to the south (160-180°); small-pebble openwork beds are 5-10 centimetres thick; some cobble beds up to 25 centimetres thick; clasts are mostly subangular but vary from angular to well rounded; dominated by clasts of varied lithologies: quartzite, diorite, sandstone, local bedrock (fine-grained igneous), basalt and vein quartz; more openwork than matrix filled in the upper part of the unit; pebble lithologies, 28% basalt, 28% metavolcanics (fine-grained, dark, andesitic?), 8% metasandstone, 8% siltstone, 8% quartzite, 8% limestone, 4% granodiorite, 4% vein quartz, and 4% other igneous intrusives (with medium-grained plagioclase, biotite, minor quartz crystals).
2	0.1 - 0.2	Fine to medium sand: planar crossbedding; unit is a coarsening upward lens that dips 12° to the southeast (160°); lower contact sharp.
1	0 - 0.1	Small to medium-pebble gravel: mainly matrix filled; matrix medium sand and coarser; minor openwork; lower contact is covered.
	Bedrock:	Limestone and interbedded siltstone: strongly fractured; fractures trend north, dip 65°-90° west (330°) some basaltic beds; abundant faults and slickensided surfaces (shear zones); clasts of basalt, siltstone, metavolcanics and limestone locally fill fractures.

Section 9042C (Trench Section)

Location: This section is located at the point where Carberry Creek flows out onto the terrace. A small alluvial fan has formed and consists, at least in the upper part, of sediments (tailings) from the Excelsior hydraulic operation.

Unit	Height above base (m)	Description:
4	6.0 - 10.0	Pebble-cobble gravel: poorly sorted; a buried soil horizon; abundant wood fragments indicate that the unit is tailings.
3	2.0 - 6.0	Cobble-gravel with some pebble-gravel beds: crudely bedded; mainly matrix filled; rarely openwork; clasts up to boulder size; boulders more concentrated to the north (upslope); discontinuous openwork beds of pebble gravel in top 2 metres; clasts are angular to subrounded; beds dip at 6° to the southwest (250°).
2	1.0 - 2.0	Small to large-pebble gravel: matrix of fine sand; clast supported to matrix supported; clasts are angular to subangular, rarely rounded; poorly sorted; beds dip 5° to the southwest; lower contact clear and dips to the southwest.
1	0 - 1.0	Small to large-pebble gravel interbedded with sand: parallel bedding; beds dip 6° to the southwest (250°); sand occurs in lenses; lower contact covered. Bedrock was not exposed but is reported to occur within 1 metre of base of section.

SITE 43 - WILLOW RIVER

Owner/operator: Alaskon Resources Ltd.
NTS: 93H/4 Wells
Latitude & Longitude: 53°07'N, 121°42'W
UTM: 5885500 m N, 587000 m E
Year of property visit: 1990

Site Description:

This site is located on a broad terrace between the confluence of the Willow River and Slough Creek to the east of Island Mountain. A large (three deck) processing plant and a few water-filled open pits were the only evidence of mining activity at the site at the time of the property visit.

Section 9043

Location: This section is on the edge of a test pit near the eastern margin of the terrace.

Unit	Height above base (m)	Description:
3	3.0 - 3.5	Fine sands: well sorted; poorly exposed; at least 50 centimetres of sand has been removed by mining from the top of the unit; lower contact clear and horizontal.
2	1.0 - 3.0	Medium-pebble gravel: mostly medium pebbles with a few beds of large pebbles and granules; crude horizontal bedding; well imbricated with paleoflow to the southwest at 220°; clast supported; matrix filled with medium sand and coarser; poorly sorted; clasts are subrounded to rounded, some subangular (mainly local vein quartz and phyllite); large-pebble and small-granule beds are mainly openwork and approximately 5 centimetres thick; medium pebble beds are 25 centimetres or more thick; pebble lithologies, 24% gneiss, 16% vein quartz, 12% phyllite, 12% metasediment, 12% quartzite, 8% schist, 4% shale, 4% sandstone, 4% chert, 4% metavolcanics, rare plutonics.
1	0 - 1.0	Pebble gravel: mostly covered; unit appears similar to Unit 2.

SITES 44 and 45 - QUESNEL RIVER

NTS: 93A/12 Hydraulic
Year of property visits: 1989

Site 44

Latitude & Longitude: 52°38'N, 121°40'W
UTM: 5833500 m N, 589800 m E

Site 45

Latitude and longitude: 52°38'N, 121°38'W
UTM: 5832300 m N, 591500 m E

Site Descriptions:

These sites are located on terraces approximately 75 metres above the Quesnel River south of Quesnel Forks. At Site 44 , a number of shallow test pits were being mined and gravels were processed through a large portable sluice plant. Site 45 was inactive when visited. Poor exposures prohibited detailed descriptions at both sites.

SITE 48 - QUESNEL RIVER

Owner/operator: Lee Frank and Debbie Corless (Corless mine)
NTS: 93G/1 Cottonwood
Latitude & Longitude: 53°01'N, 122°23'W
UTM: 5872500 m N, 542000 m E
Year of property visit: 1989

Site Description:

This site is located on a low terrace along the Quesnel River near Big Canyon, about 3 kilometres east of Quesnel. The described exposure is located near the centre of the terrace on the south side of the river.

Section 8948 (8901E)

Location The measured exposure is located near the centre of the terrace.

Unit	Height above base (m)	Description:
3	1.7 - 2.0	Small pebbly sand: horizontally laminated; fine to coarse sand, moderately sorted; some well-sorted fine sand beds; lower contact gradational.
2	0.2 - 1.7	Large-cobble to boulder gravel: crude horizontal bedding defined by well-sorted, openwork, small to medium-pebble beds; cobble and boulder beds are poorly sorted with a medium to coarse sand matrix; clasts tend to be imbricated; unit thickness varies to 3 metres; occasional large well-rounded volcanic boulders 3-5 metres in diameter occur at the base; gold occurs in the lower 0.1-3.0 metres; lower contact erosional.
1	0 - 0.2	Small to medium-pebble gravel: poorly sorted; fine to coarse sand matrix; lower contact covered.

LOW-LEVEL TERRACE SETTINGS (LOCATIONS 46 to 57)

SITES 46 and 47 - FRASER RIVER

Owner/operator: Dave and Wilf Patenaude
NTS: 93G/1 Cottonwood
Year of property visit: 1989

Site 46
Latitude & Longitude: 53°02'N, 121°33'W
UTM: 5877000 m N, 530500 m E

Site 47
Latitude and longitude: 53°05'N, 121°32'W
UTM: 5881500 m N, 531000 m E

Site Descriptions:

These sites are located on low terraces on the Fraser River north of Quesnel. Both properties are exploiting active floodplain deposits but the shallow depth of excavations prohibits detailed descriptions of the mined sediments.

SITE 49 - QUESNEL RIVER

Owner/operator: Mike Poschner
NTS: 93B/16 Quesnel River
Latitude & Longitude: 52°59'N, 122°20'W
UTM: 5868800m N, 545800m E
Year of property visit: 1990

Site Description:

This site is located on a low terrace on the southwest side of the Quesnel River across the river and downstream from Deacon Creek. The terrace is about 300 metres wide and over 1000 metres long. At the time of the property visit the terrace gravels were being evaluated with a number of test pits and a processing plant was under construction. The description of the gravels at Section 9049B (Figure 33D) was obtained immediately after excavation of one test pit. The water table in the pit was about 2 metres from the surface level and the pit quickly filled. Another test pit approximately 10 metres to the north exposed a similar sequence of medium-pebble, crossbedded, imbricated gravels.

Section 9049A

Location: This section is located in a test pit near the centre of the terrace approximately 100 metres from the river (Figure 33C).

Unit	Height above base	Description:
4	1.65 - 2.4	Fine sand: minor weak horizontal laminations; well sorted; abundant roots; lower contact is horizontal and gradational.
3	0.5 - 1.65	Large-pebble gravel: some horizontal stratification; well imbricated indicating paleoflow to the north-northwest similar to present (350°); clast supported; clasts range from small pebbles to cobbles, boulders are rare; matrix filled with mainly coarse sand; clasts are rounded to well rounded; some highly spherical clasts; some coarse cobble concentrations, particularly in the basal 30 centimetres and the upper 30 centimetres; minor openwork, medium-pebble lenses; estimated pebble lithologies, quartzite 20%, gneiss 15-20%, sandstone 15-20%, greenstone 15-20%, coarse plutonics (granites and diorites) 10%, conglomerate 5-10%, basalt 5-10%, chert less than 5% and vein quartz 5%; lower contact is sharp and erosional; scours are 20-100 centimetres wide and 10 - 30 centimetres deep.
2	0.3 - 0.5	Medium to coarse sands: trough crosslaminated with paleoflow toward the north (350°); unit is a small lens, possibly in part eroded by Unit 3; sands are well sorted with scattered granules in beds; some interbedded granule beds, about 1-2 centimetres thick; unit generally fines upwards; lower contact is gradational (sands infill the underlying gravel voids).
1	0 - 0.3	Cobble gravel: clasts range from small pebbles to boulders; matrix filled with mainly medium sand and coarser; poorly to moderately sorted; some silt patches around large clasts; lower contact covered.

Section 9049B

Location: This section is located in a test pit about 100 metres southwest of Section 9049A.

Unit	Height above base	Description:
8	5.0 - 5.5	Sand: massive to weakly laminated; well sorted; lower contact gradational.
7	4.0 - 5.0	Large pebble-cobble gravel: well imbricated indicating paleoflow to the north; lower contact clear and horizontal.
6	2.5 - 4.0	Medium to large-pebble gravel: horizontally stratified; unit fines upward; lower contact clear and horizontal.
5	2.25 - 2.5	Cobble-boulder gravel: similar to Unit 7; lower contact clear and horizontal.
4	1.5 - 2.25	Medium to large-pebble gravel: some openwork beds; oxidized in the lower 25 centimetres; lower contact clear and horizontal.
2	0.75 - 1.5	Bouldery gravel: boulders up to 1 metre in diameter; lower contact sharp and subhorizontal.
1	0 - 0.75	Medium to large-pebble gravel: matrix filled with a silty sand matrix; grey colour (unoxidized); poorly sorted; pebble lithologies, quartzite 26%, diorite/gabbro 12%, granite 8%, limestone 6%, vein quartz 6%, feldspar porphyry 4%, metabasalt 8%, greenstone 12%, siltstone 8% quartz gneiss 2%, chert 2%, arkosic, conglomerate 6%.

SITE 50 - LITTLE HIXON AND HIXON CREEKS

NTS: 93G/6
Latitude & Longitude: 53°26′N, 122°30′W
UTM: 5922000 m N, 529000 m E
Year of site visit: 1990

Site Description:

The Hixon area has a number of historically important placer-producing streams including Hixon, Little Hixon, Terry and Government creeks, but no large, active operations were visited during this study. Gold-bearing gravels in the area occur stratigraphically below a 40-metre succession of Quaternary sediments but are not exposed. In addition to buried placers, a number of terrace placers have been mined in the area and most current mining activity consists of small operations.

SITE 51 - COTTONWOOD RIVER

Owner/operator: Norm Olausen
NTS: 93G/1 Cottonwood
Latitude & Longitude: 53°05′N, 122°15′W
UTM: 588200 m N, 549500 m E
Year of property visit: 1989

Site Description:

This site is located on a low terrace of the Cottonwood River approximately 6 kilometres northwest of Cottonwood. The terrace has supported a productive mining operation for many years and parts of the terrace have been dredged in the past. The operation exploits mainly surface gravels and no deep exposures were available for description.

SITE 52 - SOVEREIGN CREEK

Owner/operator: Andy Corden
NTS: 93B/16 Quesnel River
Latitude & Longitude: 52°59′N, 122°04′W
UTM: 5870800 m N, 563100 m E
Year of property visit: 1990

Site Description:

This small operation is presently mining along the upslope edge of a small terrace paralleling Sovereign Creek about 1 kilometre upstream from its confluence with the Swift River.

Section 9052

Location: This site is located 100 metres east of Sovereign Creek on a low terrace.

Unit	Height above base (m)	Description:
3	2.0 - 3.0	Silty clay with sands: horizontally laminated; blue-grey colour; some diamicton; poorly exposed; abundant wood pieces, small twigs less than 10 centimetres long and 1 centimetre thick, some with bark; lateral extent of unit unknown due to lack of exposure but unit is reported to be 3-4 metres thick; lower contact clear and horizontal.
2	1.0 - 2.0	Large-pebble gravel: some cobbles; no apparent stratification; imbrication is present but indistinct; 80% clasts, subrounded; little matrix, mainly sand and granule gravel; poorly exposed; red colour due to oxidation; lower contact clear and horizontal.
1	0 - 1.0	Pebble to cobble gravels: rare boulders; some subhorizontal sand interbeds; otherwise no obvious stratification or imbrication; 80% clasts, rounded to subrounded, mostly large pebbles; matrix of fine sands with granules; sandy beds less than 10 centimetres thick and well sorted; unit locally contains diamicton intraclasts; grey colour; lower contact covered.

DRAGON MOUNTAIN PLACERS LTD.

Owner/operator: Stuart Spiers and Don Kirkham
NTS: 93B/16 Quesnel River
Latitude & Longitude: 52°59'N, 122°02'W
UTM: 5870900 m N, 564800 m E
Year of property visit: 1992

Site Description:

A large exploration program was recently conducted by the Malaysian Mining Corporation in the Sovereign Creek area, about 2 kilometres upstream from the above property. The program targeted a potential buried channel system originally identified from satellite data. The property is now owned by Dragon Mountain Placers Limited. Recent mining along the periphery of the channel has exposed gold-bearing gravels that underlie glaciolacustrine sediments and till. A more detailed discussion of the geology at this site is provided earlier in this report.

SITE 53 - COTTONWOOD RIVER

Owner/operator: Don Carter
NTS: 93G/1 Cottonwood
Latitude & Longitude: 53°03'N, 122°09'W
UTM: 5876800 m N, 557800 m E
Year of property visit: 1990

Site Description:

This site is located along the Cottonwood River approximately 2 kilometres southeast of Cottonwood. The described section is in a natural cut-bank exposure.

Section 9053

Location: This site is located on a low terrace on the north side of the Cottonwood River.

Unit	Height above base (m)	Description:
10	4.1 - 4.5	Silt and fine sand: horizontally laminated to thickly bedded; locally massive; some pebbles; unit is up to 1 metre thick in places; lower contact gradational.
	93.6 - 4.1	Small to medium-pebble gravel: trough cross-stratified with small scour-fill structures; moderately well sorted; minor openwork, manganese-stained beds near the base; clasts moderately to well rounded; lower contact is erosional to gradational.
8	3.1 - 3.6	Sandy large-pebble to small-cobble gravel: horizontal bedding (very crude); weakly imbricated; moderately well sorted; matrix is medium sands and coarser; clasts moderately to well rounded; iron oxides give the unit an orange stain; lower contact is planar and subhorizontal.
7	2.7 - 3.1	Medium to large-pebble gravel: some openwork small-pebble lenses and some cobbly beds; clasts are imbricated indicating paleoflow towards the west (290°); moderately sorted; clasts moderately to well rounded; unoxidized; abundant quartzites, metavolcanics and metasediments; some shale,

		mafic volcanics (porphyritic with hornblende crystals), diorite, gneiss, vein quartz; the unit is lens shaped with a maximum thickness of 150 centimetres and width of 25 centimetres; lower contact is trough shaped.
6	2.3 - 2.7	Sandy medium-pebble gravel: planar crossbedded; beds are mostly 2-5 centimetres thick and have an apparent dip of 5° to the north, decreasing up section; upper 10 centimetres is a lens of pebbly coarse sand fining upwards to granular sands about 5 metres wide; unit thickens to the north; some small to medium openwork pebble beds; maximum thickness of unit is 2 metres; some conglomerate boulders; lower contact is erosional, marked by a large-pebble lag to the south and a cobble to boulder lag to the north where the lower contact dips steeply southwards; cobble lag is strongly oxidized (iron).
5	2.1 - 2.3	Gravelly breccia with abundant silt intraclasts: internally beds/laminae are 1-2 centimetres thick; abundant sand; bed has a constant thickness; gravel mainly pebbles of various lithologies; lower contact is conformable and dips to the north.
4	1.6 - 2.1	Sandy small to medium-pebble gravel: large-scale planar crossbeds; beds 1-4 centimetres thick dipping north; minor openwork beds; well imbricated; unit grades towards the south into a laminated medium sand; pebbles are well rounded; lower contact is planar, dips to the north and is conformable.
3	1.3 - 1.6	Medium sand with abundant fine sand intraclasts: intraclasts are angular, tabular and dip to the north; well sorted; unit is a trough-shaped lens about 3 metres wide; lower contact is strongly undulatory and erosional, it is marked in places by a pebble lag or concentrations of intraclasts.
2	0.5 - 1.3	Clays and silts: brecciated, strongly deformed (sheared and brecciated); thrust contact with the underlying sands is brecciated and slickensided; undisturbed zones where the unit is not brecciated and some stratification is preserved occur away from the thrust contact; the unit has less than a metre of vertical exposure but, due to tilting of the beds, a stratigraphic thickness of several metres is exposed along the upper contact; lower contact is a brecciated and slickensided thrust plane (slickensides trend at 245° parallel to the dip of the thrust plane).
1	0 - 0.5	Fine to medium sand: unit has been tilted to the south and dips 35° towards 175°; unit is at least 5 metres thick stratigraphically; silts and clays overlie and are in thrust contact with the sands; lower contact not exposed.

SITE 54 - LIGHTNING CREEK

Coldspring House area
Owners/operators: Mike Poschner, John Bot
NTS: 93G/1 Cottonwood
Latitude & Longitude: 53°01′N, 122°05′W
UTM: 5875000 m N, 561000 m E
Year of property visit: 1990

Mexican Hill
Owner/operator: Masoro Mining Company
NTS: 93G/1 Cottonwood
Latitude and longitude: 53°01′N, 122°04′W
UTM: 5874400 m N, 562000 m E
Year of property visit: 1990

Site Description:

There are a number of mining operations in the Coldspring House area. Most are small mines exploiting Holocene gravels on a series of low terraces along the north side of Lightning Creek just upstream from its confluence with the Swift River, west of Coldspring House. The mines were not operating when they were visited but the presence of mining equipment and recent excavations indicated that the area was still active. The mined sediments were poorly exposed and none of the shallow excavations were suitable for description.

The Mexican Hill mine is a large operation located on a series of benches on the south side of Lightning Creek, southeast of Coldspring House. The property has been logged and a large processing plant was on the site but no mining was in progress. The described exposure is located on the north side of the valley at the level of the highest bench.

Section 9054

Location: This section is located on the north side of the Lightning Creek valley in the Mexican Hill area.

Unit	Height above base (m)	Description:
5	8.25 - 9.0	Fine sand: horizontally laminated; well sorted; lower contact sharp and horizontal.

4	8.0 - 8.25	Medium-pebble gravel: horizontally bedded; clast supported; matrix filled with fine sand and coarser; minor openwork lenses; clasts are subrounded to well rounded; lower contact sharp and subhorizontal.
3	6.0 - 8.0	Fine sand: horizontal and trough crossbed sets with internal laminae; well sorted; some pebbly sand in upper part; beds are 20-50 centimetres thick; lower contact sharp and horizontal.
2	2.0 - 6.0	Large-pebble gravel fining upward to small to medium-pebble gravel, with some large pebbles: crude horizontal bedding; clast supported; matrix filled with fine sand and coarser; more matrix in the upper 2 metres; minor openwork lenses (5-10 centimetres thick by 50-100 centimetres wide); clasts are subrounded to well rounded; patches of iron oxide staining occur in the upper 1.5 metres; lower contact sharp and horizontal.
1	0 - 2.0	Silty sand diamicton: massive; matrix supported; pebbles mostly subrounded and up to large-pebble size; varied lithologies; some striated; lower contact covered.

SITE 55 - LIGHTNING CREEK

Owner/operator: Dan Romanow
NTS: 93H/4 Wells
Latitude & Longitude: 53°03'N, 121°59'W
UTM: 5877000 m N, 568800 m E
Year of property visit: 1989, 1990

Site Description:

This open-pit mine is located on a low terrace with a shallow water table on the south side of Lightning Creek, downstream from Wingdam. Gravels were mined from a bedrock gutter (small channel) on the terrace in 1989 and 1990. A drilling program on the lower slope of the south valley wall was begun in the latter part of the 1990 season .

Section 8955A

Location: This section is a north-facing exposure at the base of the valley wall approximately 150 metres south of Lightning Creek

Unit	Height above base (m)	Description:
10	4.65 - 5.65	Pebbly silty sand: very crude, irregular stratification; clasts are up to small-cobble size; oxidized and unoxidized mottles; lower contact is covered.
9	4.4 - 4.65	Covered.
	4.2 - 4.4	Fine sand with silt interbeds: highly irregular and deformed laminations; well sorted; lower contact is clear and planar.
8	4.1 - 4.2	Granule to medium-pebble gravel: unit is a small lens about 1 metre wide; poorly sorted; lower contact is diffuse.
7	3.8 - 4.1	Fine to medium sand with scattered pebbles: deformed laminations; subhorizontal bedding; lower contact clear and horizontal.
6	3.65 - 3.8	Fine sand with silt: some medium sand beds; well laminated with minor deformation; very well sorted; lower contact clear and horizontal.
5	2.9 - 3.65	Fine to medium sand with scattered pebbles: deformed laminations; subhorizontal bedding; lower contact clear and horizontal.
4	2.15 - 2.9	Fine sand and silt: thick horizontal beds; irregular bed contacts; numerous oxidized strata, usually the coarser beds; few pebble layers, silty beds are mainly unoxidized (grey in colour) with oxidation confined to small zones around organics and small pebbly or sandy interbeds; lower contact is conformable.
3	0.95 - 2.15	Fine sand and pebbly sand with minor gravel lenses or beds: thick horizontal beds; weathered surfaces show irregular internal laminations in the sandy beds; some silty beds, up to 2 centimetres thick; unit is partially oxidized, mottling is common throughout; lower contact is conformable.
2	0.75 - 0.95	Medium sand: crude horizontal stratification; some mottling; lower contact is planar.
1	0 - 0.75	Cobble gravel: clast supported, matrix filled; sandy pebble matrix; poorly sorted; clasts are mostly rounded, (subangular to well rounded); cobbles are mainly quartzite, gneiss, schist, igneous and quartz; imbricated (paleoflow down and parallel to the modern valley); lower contact covered. Bedrock: Located close to the base of this gravel but not currently exposed. Gold is found in the lowermost gravels, just above bedrock.

Section 8955B

Location: This section was measured in an active pit on a low terrace south of Lightning Creek, approximately 50 metres north of Section 8955A. The water table was near the surface.

Unit	Height above base (m)	Description:
5	2.8 - 3.0	Fine sand and silt: irregular horizontal laminations; oxidized mottles; lower contact sharp and planar.
4	2.6 - 2.8	Fine and medium sand; horizontally laminated beds with small trough-shaped beds of coarse sand to small pebbles; unit fines upwards; sands well sorted; lower contact is clear and undulatory.
3	1.85 - 2.6	Cobble gravel: crudely imbricated; clast supported; matrix filled; medium sand to large-pebble matrix; poorly sorted; locally oxidized; clasts are rounded; lower contact is clear and planar.
2	1.0 - 1.85	Medium-pebble and large-pebble gravel: horizontally bedded; beds 15-25 centimetres thick; clast supported; matrix filled; moderately sorted; locally oxidized; matrix of silty sand.
1	0 -1.0	Medium-pebble and large-pebble gravel with some cobble and boulder beds near the base of the unit: horizontally bedded; beds 15-25 centimetres thick; clast supported; matrix filled with silty sand; locally oxidized; clasts are subrounded; moderately to well sorted; some well-developed manganese-stained layers; lower contact covered. Gold presumably comes from these gravels which are in contact with bedrock approximately 50 centimetres below the base of the exposed section.

SITE 56 - QUESNEL RIVER

Owner/operator: Elmer Sommerfelt
NTS: 93A/12 Hydraulic
Latitude & Longitude: 52°40'N, 121°53'W
UTM: 5834000 m N, 575300 m E
Year of property visit: 1990

Site Description:

This site is located on a low terrace on the south side of the Quesnel River, 5 kilometres upstream from the Buxton Creek road and Hydraulic road junction.

Section 9056

Location: This section is located along a trench on the edge of a broad channel in the terrace, about 175 metres from the Quesnel River.

Unit	Height above base (m)	Description:
4	8.0 - 8.5	Coarse sand and granules interbedded with small pebbly gravel: beds 1-5 centimetres thick; gradational lower contact.
3	7.3 - 8.0	Small to medium-pebble gravel interbedded with granular sand: beds dip 3° toward the valley centre (north at 000°).
2	5.0 - 7.3	Interbedded large-cobble and medium to large-pebble gravel: horizontally bedded; well imbricated; matrix of coarse to medium sand (moderately sorted); gravel poorly sorted; clasts mostly rounded to well rounded, some subangular; paleoflow is to the west; large boulders (>1 metre) occur at the base of the unit; lower contact covered.
1	0 - 5.0	Silt and clay: very well sorted; clay rich; not exposed at present but has been stockpiled during mining activity. Samples: 9014 - fine tailings; 9015 - black sand from sluice box.

SITE 57 - CARIBOO RIVER

NTS: 93A/12 Hydraulic
Latitude & Longitude: 52°39'N, 121°40'W
UTM: 5835900 m N, 589800 m E
Year of property visit: 1990

Site Description:

This small open-pit mine is located at Quesnel Forks on a low terrace 10 to 15 metres above the level of the Cariboo River, approximately 500 metres upstream from the confluence of the Quesnel and Cariboo rivers. Other operations in the area include a large open-pit mine on the northwest side of the Quesnel River.

Section 9057

Location: A low terrace at the junction between the Cariboo and Quesnel rivers (Quesnel Forks).

Unit	Height above base (m)	Description:
5	1.3 - 1.7	Interbedded medium and large-pebble gravel: planar cross-stratification and trough cross-stratification; some openwork, mostly matrix filled; matrix of medium sand and coarser; clasts subangular to well rounded; lower contact subhorizontal and clear.
4	1.1 - 1.3	Small to medium-pebble openwork gravel: planar crossbedded; strong manganese staining, clasts subangular to well rounded, mainly rounded; lower contact subhorizontal and clear.
3	0.7 - 1.1	Large-cobble gravel with some boulders: clast supported; openwork; small to large-pebble gravel occurs between larger clasts; abundant manganese and iron staining; clasts are subangular to well rounded; lower contact subhorizontal and clear.
2	0.3 - 0.7	Medium to large-pebble gravel: crude horizontal bedding; varies from openwork to matrix filled (coarse sand matrix); clasts mostly rounded (subangular to well rounded); lower contact subhorizontal and clear.
1	0 - 0.3	Silty to sandy pebble gravel: matrix filled; matrix silts to coarse sands; clasts are medium to large pebbles; clasts are subangular to well rounded; poorly sorted; poorly exposed; lower contact covered.

COLLUVIAL AND ALLUVIAL FAN SETTINGS (LOCATIONS 58 to 61)

SITE 58 - SLOUGH CREEK (Point Bench)

Owner/operator: Roy and Dusty Trites
NTS: 93H/4 Wells
Latitude & Longitude: 53°06'N, 121°42'W
UTM: 5882500 m N, 588200 m E
Year of property visit: 1990

Site Description:

This site is located along Slough Creek downstream from its confluence with Devils Lake Creek. The area was the focus of a large hydraulic operation on the lower slopes of Mount Nelson. Section 9058A was described in a small open pit near the upper limit of the former hydraulic operation and Section 9058B was located in an excavation on low terrace in the Slough Creek valley.

Section 9058A

Location: This section is located on the lower slopes of Mount Nelson below the level of Hong's ditch and about 1 kilometre east of Nelson Creek.

Unit	Height above base (m)	Description:
4	4.2 - 4.7	Pebble to boulder gravel: size sorting, stacking and absence of matrix indicate that these gravels are hand stacked tailings (typical of the region).
3	3.2 - 4.2	Diamicton: very crude subhorizontal stratification; minor discontinuous and irregular sandy laminae; clast to matrix supported; loose silty sand matrix; about 40-50% clasts up to boulder size; abundant angular to subrounded clasts, some striated; probably colluviated sands and gravels; lower contact indistinct.
2	2.0 - 3.2	Small-cobble to small-boulder gravel: clast supported; matrix filled; matrix of very well sorted, fine sands; sands are horizontally laminated; oxidized; clasts rounded to well rounded; unit is weakly cemented.
1	0 - 2.0	Bedrock: black phyllite; thin quartz veins up to 2 centimetres thick with some pyrite and chalcopyrite mineralization; foliation striking 110° and dipping 65° to the northeast; joints and foliation surfaces are strongly oxidized in the upper metre; bedrock surface undulates and rises steeply at 35-40° upslope toward the southwest (200°).

Section 9058B

Location: This section is located on a forested bench in the Slough Creek valley near the old mining camp.

Unit	Height above base (m)	Description:
2	1.0 - 2.0	Pebble to boulder gravel: crude horizontal bedding; unit consists of ~50% pebbles and 50% cobbles and boulders; clast supported; matrix filled; sandy matrix; unit fines upwards from boulders at the base to small to large pebbles at the top; lenses of pebble gravel are common; bouldery gravel beds are very poorly sorted; finer gravel is moderately sorted and crudely stratified; boulders, often schistose or phyllitic, are mostly angular, some subangular and rarely rounded; openwork small to medium-pebble lenses occur in the lee of large boulders; most beds are oxidized (iron); lower contact is undulatory and erosive.
1	0 - 1.0	Small to medium-pebble gravel: crude imbrication and horizontal stratification; mainly openwork gravel beds; locally some (<10%) matrix; matrix when present is fine to coarse sands, some silts; gravels are brown to grey in colour (unoxidized); imbrication indicates paleoflow towards the northeast; clasts are subangular to rounded; mixed lithologies; basal contact is covered.

SITE 59 - WILLIAMS CREEK

Owner/operator: Sam Taylor
NTS: 93H/4 Wells
Latitude & Longitude: 53°06'N, 121°30'W
UTM: 5883000 m N, 600100 m E
Year of property visit: 1990

Site Description:

This small open-pit mine is located on a sloping bedrock bench (Devlin's Bench) on the north side of Williams Creek, north of the Wells airstrip. The site is adjacent to a large pond remaining from a recent dredging operation in the Williams Creek Flats.

Section 9059

Location: This section is on the north rim of Williams Creek valley on a low bedrock bench (Figure 34A).

Unit	Height above base (m)	Description:
5	4.8 - 5.3	Soil horizon, organic mat, abundant logs and rootlets.
4	4.3 - 4.8	Diamicton: with irregularly shaped lenses of medium to large-pebble gravel; beds dip to the south (valley centre); unit consists of tailings and overburden from dredging operation, includes logs and other organics.
3	2.9 - 4.3	Medium to large-pebble gravels: very crude horizontal bedding; matrix is mostly coarse sands and granules, some medium sands; moderately sorted; abundant tabular clasts; some openwork lenses; clasts angular to well rounded; some thin, small pebbly lenses,10 centimetres thick and 25 centimetres wide, with more well-rounded clasts; lower contact is erosional and slightly scoured.
2	0.6 - 2.9	Medium to large-pebble gravel interbedded with a small to medium-pebble gravel: horizontally bedded; coarser beds are poorly sorted with a matrix of fine to coarse sand and minor silt; 25-50 centimetres thick; chaotic fabric; clasts are 50% angular local phyllite and 50% subangular to rounded quartzite, gneiss, vein quartz, and limestone; small to medium-pebble beds are openwork, and about 10 centimetres thick; lower contact is horizontal and clear.
1	0 - 0.6	Small-pebble sandy gravel: medium to coarse sand; moderately well sorted; lower contact is onto bedrock which is broken and weathered with a soft silty clay layer directly on its surface.
	Bedrock:	Phyllite: possibly a very low-grade chlorite-muscovite schist; orange-red to greenish grey; has abundant disseminated pyrite cubes; also has quartz stringers/veins; foliation dips 70° to the southwest (230°); the upper bedrock surface slopes 15-20° to the southwest (205°) down onto a narrow bench along the margin of the old Williams Creek channel. The old channel is oriented east-west (105°).

SITE 60 - BIG VALLEY CREEK

Owner/operator: Al Bolduc
NTS: 93H/4 Wells
Latitude & Longitude: 53°11'N, 121°35'W
UTM: 5892100 m N, 595400 m E
Year of property visit: 1990

Site Description:

This small open pit-mine is located on the south side of Big Valley Creek. The site is located at the base of an old hydraulic mine along the valley wall.

Section 9060A

Location: This section is located on the lower slope on the south side of the valley. The described section was a poor exposure in a pillar between two old hydraulic pits.

Unit	Height above base (m)	Description:
4	6.0 - 9.0	Large-pebble to cobble gravel laterally grading into diamicton: crude horizontal stratification; matrix supported; poorly sorted; lower contact indistinct and subhorizontal.
3	4.0 - 6.0	Pebble gravel: crude horizontal stratification; similar to Unit 1 below; lower contact indistinct and horizontal.

2	2.0 - 4.0	Cobble gravel: crude horizontal stratification; clast supported; sandy matrix; poorly sorted; lower contact indistinct and horizontal.
1	0 - 2.0	Medium to large-pebble gravel: crude horizontal stratification; matrix to clast supported; sandy matrix; poorly sorted; lower contact covered.

Section 9060B

Location: This section is located in an active open pit at the base of the valley slope on a small terrace.

Unit	Height above base (m)	Description:
2	4.0 - 6.0	Interbedded cobble, pebble and sand layers: unit is mainly tailings and possibly some colluvium.
1	0 - 4.0	Large-pebble to small-cobble sandy gravel: poorly to moderately sorted; well-rounded to subrounded clasts; horizontally laminated sand lenses, 20 centimetres thick and several metres wide; gravels loose and unconsolidated; locally oxidized; unit grades laterally into medium-pebble gravels; lower contact covered.

SITE 61 - NELSON CREEK

Owner/operator: Bill Dyson / Bill and Mike McCullagh
NTS: 93H/4 Wells
Latitude & Longitude: 53°06'N, 121°42'W
UTM: 5882800 m N, 587100 m E
Year of property visit: 1990

Site Description:

This site is located on the east side of Nelson Creek. The area has been the focus of mining operations for many years including old hydraulic operations. Section 9061A is located close to the western edge of one old hydraulic pit (Hong's pit). Bedrock exposed at the base of Section 9061A forms the west rim of the pit. Section 9061B is located further upslope, in an active part of the mine site along a highwall parallel to Nelson Creek.

Section 9061A

Location: The described section is approximately 25 metres to the east of the present mine. It is exposed along a roadcut and faces toward the northeast (Figure 34B).

Unit	Height above base (m)	Description:
7	5.5 - 7.5	Silty sand gravel: matrix supported; 50-60% clasts, mostly medium to large pebbles; poorly sorted; poorly exposed.
6	3.5 - 5.5	Interbedded sandy gravel and sand: sands occur as trough-shaped lenses, 20-40 centimetres thick, up to 2 metres wide, horizontally laminated to massive, well-sorted, fine sands with minor silt and scattered small pebbles; sandy gravel beds are bimodal; a sandy cobble bed, about 30 centimetres thick, occurs at 230-260 centimetres; a sandy medium to large-pebble bed occurs at 290-330 centimetres; a small granular lens occurs at 210-230 centimetres; clasts are subangular to rounded greenstone, shale, quartzite, vein quartz and metasediment; contacts between beds are gradational and subhorizontal.
5	3.25 - 3.5	Silty diamicton: similar to Unit 7; matrix supported; mostly medium to large pebbles; poorly sorted; lower contact gradational.
4	2.75 - 3.25	Sandy diamicton: similar to Unit 7 except matrix is a little better sorted and locally is laminated; lower contact gradational.
3	1.75 - 2.75	Cobble-boulder gravel: poorly sorted; sandy matrix; rocks are subangular; clast supported; lower contact covered.
2	1.0 - 1.75	Covered
1	0 - 1.0	Diamicton: 50-60% clasts; mostly angular fragments of local schist with a crude imbrication; Flow is suggested toward 050°; matrix is a silty sand, compact and there are thin lenses of well-sorted, fine sand, 1 centimetre thick and 20 centimetres wide; lower contact is sharp and horizontal to subhorizontal.
	Bedrock:	Schist: dark grey colour; foliation strikes at 185° and dips 50° to the east, friable, easily broken along foliation.

Section 9061B

Location: The described section is a north-south oriented wall in the active pit.

Unit	Height above base (m)	Description:
4	2.5 - 2.8	Diamicton: matrix supported; matrix is a fine sandy silt; clasts are mostly pebble size; cobbles and boulders rare; about 30% clasts; closely spaced jointing pattern allows the diamicton to be broken into small cubes; oxidized; loose; upper surface has been bulldozed; unit thickens upslope to about 100 centimetres where there are more striated clasts and a higher silt content in the matrix; lower contact is sharp and horizontal.
3	1.0 - 2.5	Silts coarsening upward into fine sands: pebbly in the lower 25 centimetres (silty); locally is weakly laminated; upper sandy zone has many convoluted laminations and thin beds; well sorted; silts are mottled with oxidized and unoxidized zones; unit thickens laterally and is locally clay rich; lower contact is undulatory and gradational.
2	0.5 - 1.0	Sandy gravel: clast supported; mostly small to medium pebbles near the top and more large pebbles near the base; poorly sorted; very crudely bedded due to slightly more well-sorted areas; clasts are subangular to subrounded; some angular clasts of local bedrock; oxidized in places; most clasts are horizontal, flat lying; gold bearing; lower contact is covered.
1	0 - 0.5	Large-pebble to cobble gravel: unit is mostly covered but is reported to be 3 metres thick, compact and very hard, poorly sorted and may contain boulders; this is the main gold-bearing unit.

APPENDIX C - LITHOLOGY OF SELECTED PEBBLE SAMPLES (%)

Section #	Unit #	Quartzite	Basalt	Rhyolite	Andesite	Other volc.	Chert	Diorite	Granitite	Other Intru.	Vein quartz	Sandstone	Siltstone	Shale	Mudstone	Limestone	Dolostone	Carbonates	Quartz gneiss	Other gneiss	Muscovite schist	Biotite schist	Chlorite schist	Other schist	Slate	Phyllite	Metasediments	Metavolcanics	Other	Total
8901F	2	28	0	0	2	10	10	2	0	8	12	0	8	8	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	100
8901H	1	44	0	0	2	18	14	0	2	12	2	0	0	0	4	0	0	0	0	2	0	0	0	0	0	0	0	0	0	100
8901H	9	64	4	0	0	12	4	4	0	4	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
8901I	12	50	0	0	0	0	30	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
8901J	2	54	26	0	0	6	6	4	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
8901L	1	74	0	0	0	10	12	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
8901L	3	54	0	0	0	6	14	4	0	6	6	8	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	100
8901L	4	7	23	0	12	16	0	0	7	9	7	5	0	9	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
8901L	5	32	12	6	2	0	2	8	10	0	10	0	4	0	0	4	0	0	2	0	0	0	0	0	0	0	0	8	0	100
8901M	1	20	0	0	0	40	10	0	0	10	0	0	0	10	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	100
9002*	4	62	0	0	3	1	0	0	0	14	4	0	0	7	0	0	0	0	1	0	0	3	0	0	0	1	4	0	0	100
9002*	T	43	4	7	8	8	0	0	0	8	11	0	0	0	7	0	0	0	0	0	1	2	0	0	0	0	1	2	0	100
9004	2	24	16	0	0	4	16	0	0	0	32	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	100
9004	4	20	8	0	24	0	12	4	0	0	20	0	8	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	100
9006	1	10	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	20	45	0	0	0	0	0	0	5	0	100
9010	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	4	20	0	8	0	0	28	12	0	0	100
8914A	1	8	8	0	0	0	4	0	0	0	16	4	0	8	8	0	0	0	16	8	0	0	0	16	0	0	0	0	4	100
8914A	4	0	28	4	0	0	0	0	0	0	16	16	0	0	4	0	0	0	0	16	0	0	0	16	0	0	0	0	0	100
8914A*	11	25	10	0	0	0	0	0	0	0	10	2	41	0	0	0	0	0	0	6	6	0	0	0	0	0	0	0	0	100
8914A	12	32	4	0	0	0	0	0	0	0	16	8	8	0	0	0	0	0	28	4	0	0	0	0	0	0	0	0	0	100
8914A	16	25	30	4	0	0	0	13	4	0	8	0	0	0	0	0	0	0	0	8	0	0	0	0	8	0	0	0	0	100
8914B	4	12	14	0	0	4	2	0	0	0	24	0	6	0	0	0	0	0	6	10	14	6	0	2	0	0	0	0	0	100
8915B	2	26	0	0	0	0	0	0	0	11	24	0	6	0	0	0	0	0	0	15	0	0	0	16	2	0	0	0	0	100
8915F	1	16	12	0	0	0	0	0	0	0	32	8	16	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	4	100
8915F	4	16	0	0	0	0	0	4	0	0	12	4	32	0	12	0	0	0	0	12	0	0	0	8	0	0	0	0	0	100
8915F	13	16	16	0	0	0	8	6	2	0	14	2	8	2	0	0	0	0	8	0	0	0	0	10	0	8	0	0	0	100
9015H	3	8	0	0	4	0	0	0	0	0	12	0	0	48	0	0	0	0	0	8	0	0	0	4	0	0	0	16	0	100
9015H	5	36	0	0	0	0	0	4	0	0	16	0	0	16	0	0	0	0	8	0	8	0	0	0	0	0	4	4	4	100
9016*	2	8	4	0	6	8	0	0	0	0	0	2	8	0	0	0	0	0	0	0	18	0	0	0	0	36	10	0	0	100
9016*	9	12	16	0	0	12	0	0	0	0	8	2	2	0	0	0	0	0	0	0	24	4	2	0	0	8	8	0	0	100
9016*	12	16	4	0	4	8	0	0	0	0	2	12	0	0	0	0	0	0	0	0	0	0	0	32	0	16	6	0	0	100
9016	23	12	0	0	0	0	0	0	0	16	20	4	0	0	0	0	0	0	4	12	0	0	0	8	0	24	0	0	0	100
9018A*	1	35	20	0	10	6	0	0	0	0	5	0	3	0	0	0	0	0	0	5	5	3	0	0	0	6	2	0	0	100
9018B	2	40	0	0	0	0	0	8	0	0	12	0	0	0	0	0	0	0	16	0	0	8	0	0	0	4	12	0	0	100
9018B	6	24	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	28	24	0	0	0	0	0	4	12	0	100
9018B	8	16	0	0	0	0	0	0	0	0	8	0	4	0	0	0	0	0	0	28	0	0	0	28	0	0	0	16	0	100
8921B	8	8	8	0	8	0	0	4	0	0	0	12	28	0	0	0	0	0	0	4	0	0	0	0	0	0	0	28	0	100
8921B	11	8	8	0	12	0	0	0	0	0	4	4	48	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	12	100
9022A*	3	24	7	0	4	2	0	0	0	0	2	9	16	0	0	0	0	0	0	0	0	0	0	7	0	7	13	9	0	100
8923	2	16	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	28	0	0	0	0	48	0	0	0	0	0	100
8923	3	32	0	0	0	0	0	0	0	4	12	0	4	0	0	0	0	16	0	8	0	0	0	24	0	0	0	0	0	100
9023	4	16	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	8	2	0	0	0	8	0	52	0	2	0	100
9024A	2	15	0	0	0	0	0	2	0	0	13	0	0	5	0	2	0	0	25	8	0	0	0	10	0	5	12	3	0	100
9024A	6	4	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	56	4	0	0	0	8	4	8	4	0	0	100
8929A	6	18	16	0	0	0	0	0	0	0	4	0	6	0	0	36	0	0	0	0	0	0	0	18	0	0	0	0	2	100
8929A	1	32	0	0	0	0	4	0	0	0	20	2	0	0	0	0	0	0	22	0	0	0	0	20	0	0	0	0	0	100
8929B	5	28	4	0	0	0	0	2	0	0	12	0	0	0	0	0	0	0	32	0	0	0	0	22	0	0	0	0	0	100
8929E	7	42	22	0	0	0	0	0	0	0	12	0	0	0	0	4	0	0	8	0	0	0	0	8	0	0	0	4	0	100
8929E	1	32	4	0	0	0	0	0	0	4	0	0	8	0	0	16	0	0	16	0	0	0	8	12	0	0	0	0	0	100
8929NE	4	0	8	0	0	0	0	0	0	8	4	0	4	0	0	56	0	0	0	0	0	0	0	4	0	16	0	0	0	100
8929R	3	39	4	0	0	0	0	4	0	0	14	0	0	0	0	14	0	0	14	0	0	0	0	11	0	0	0	0	0	100
9036B	1	12	52	0	0	0	0	8	4	0	0	0	0	0	0	0	0	0	0	0	16	0	8	0	0	0	0	0	0	100
9036B	5	4	36	0	0	0	4	0	8	16	4	0	0	0	0	0	0	0	4	0	0	20	0	0	0	4	0	0	0	100
9037	2	10	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	25	15	0	0	0	20	0	5	0	0	0	100
9039A	1	32	0	0	8	0	0	8	0	0	12	0	0	4	0	8	0	0	0	4	0	0	0	16	0	8	0	0	0	100
9040*	3	6	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	19	0	0	0	27	27	2	0	100
9041A	6	12	0	0	0	0	0	0	0	0	24	0	0	8	0	0	0	0	24	4	0	0	0	20	0	0	8	0	0	100
9041C	2	15	0	0	0	0	0	0	0	4	15	0	0	0	0	0	0	0	22	12	0	0	0	20	0	0	4	8	0	100
9042B	3	8	28	0	0	0	0	4	0	4	4	0	8	0	0	8	0	0	0	0	0	0	0	0	0	0	8	28	0	100
9043	2	12	0	0	0	0	4	0	0	0	16	4	0	4	0	0	0	0	0	24	0	0	0	8	0	12	12	4	0	100
9049B	1	26	12	0	0	0	2	0	8	4	6	0	8	0	0	6	0	0	2	0	0	0	0	0	0	0	0	20	6	100

** Samples analyzed by lab technician (J. Borges - British Columbia Geological Survey). All other samples analyzed by authors.*

APPENDIX D HISTORICAL PLACER PRODUCTION

A brief summary of historical gold production in the Cariboo is provided below as an analysis of past production in some regions can help to determine potential production in nearby areas with similar geologic characteristics. It needs to be emphasized, however, that production data should not be used in isolation from geologic information when mining and exploration decisions regarding potential productivity are made on untested ground. In addition to the production data given, records of gold fineness, as recorded by Holland (1950) for each placer area, are also provided where available [fineness = 1000 x% gold / (% gold +% silver)]. These data are included here as fineness is a useful tool in categorizing placer gold deposits of similar origin and, in conjunction with production and geologic data, may help to determine production potential of new prospects. For example, analysis of fineness data may help confirm interpretations, regarding placer source and potential, inferred from known geologic relationships between a placer area under investigation and a nearby area of good historical production.

As there currently is no systematic collection of placer gold production data in British Columbia, only historical data from a period of relatively good record maintenance (1874 - 1945) are presented here. Gold production records for this period are listed alphabetically for selected Cariboo placer areas and in order of decreasing production. All the placer streams and areas listed are shown on Figures 6 to 12. Records for many areas are incomplete and approximately 30% of the total gold production from the region was mined before 1874, prior to record keeping by the Ministry of Mines. More detailed information on historical gold production can be found in Holland (1950).

TABLE 1
ALPHABETIC LISTING OF RECORDED GOLD PRODUCTION FROM SELECTED CARIBOO PLACER AREAS, 1874 - 1945*

Placer Stream or Area	Recorded Gold Production Grams	Recorded Gold Production Ounces	Average Gold Fineness # of samples)
Amador Creek	5,550	178	847.5 (1)
Antler Creek	1,046,600	33,652	828 (19)
Barr Creek	13,600	438	902 (7)
Beggs Gulch	n.d.	---	796 (7)
Big Valley Creek	29,150	937	882.5 (2)
Black Creek	1,900	62	811 (1)
Burns Creek	175,900	5,655	914 (3)
Butcher Bench	6,700	216	879.5 (6)
California Gulch	4,230	136	n.d.
Canadian Creek	6,950	224	824.5 (2)
Cariboo River	258,050	8,297	851 (10)
Cedar Creek	1,175,100	37,784	819.5 (5)
Chisholm Creek	n.d.	---	910 (2)
Conklin Gulch	228,350	7,342	811(29)
Cottonwood River	310,500	9,984	901 (6)
Coulter Creek	31,550	1,015	900 (3)
Cunningham Creek	399,850	12,857	861.5 (10)
Devils Lake Creek	14,350	462	905 (6)
Donovan (Poorman) Creek	60,550	1,947	907 (15)
Dragon Creek	77,700	2,498	907 (8)
Eight Mile Creek	217,150	6,982	866.5 (1)
Four Mile Creek	22,350	718	n.d.
Frank (Goose) Creek	8,900	286	n.d.
Fraser River (Prince George to Quesnel	885,500	28,475	868 (5)
Fraser River (Quesnel to Williams Lake	499,850	16,073	872 (10)
French Creek	107,350	3,452	844 (13)
French Snowshoe Creek	12,750	410	834 (3)
Grouse Creek	448,900	14,435	823 (32)
Grub Gulch	11,650	375	885 (9)
Hardscrabble Creek	n.d.	---	867 (1)
Harveys Creek	119,800	3,853	901 (16)
Hixon Creek	157,400	5,061	852 (1)
Horsefly River (Hobsons)	473,200	15,216	841 (6)
Houseman Creek	8,250	266	871 (1)
Hyde Creek	2,750	89	908 (1)
Jack of Clubs Creek	215,100	6,916	877 (40)
Kong Fu Creek	2,900	94	911.5 (15)
Kangaroo Creek	8,550	275	n.d.
Keithley Creek	1,100,800	35,395	897 (26)
Last Chance Creek	41,250	1,327	899 (3)
Lawless (Half Mile) Creek	12,700	408	833.5 (3)
Lightning Creek	3,066,500	98,602	890 (75)
Lightning Creek (at Stanley)	82,400	2,649	891 (12)
Lightning Creek (at Wingdam)	859,850	27,648	910.5 (9)
Little Snowshoe Creek	35,800	1,151	888 (16)
Little Swift River	450	15	n.d.
Lowhee Creek	2,302,100	74,022	889 (27)
Mary Creek	1,300	41	n.d.

Placer Stream or Area	Recorded Gold Production (grams)	Recorded Gold Production (ounces)	Average Gold Fineness (# of samples)
McMartin (Martin) Creek	11,300	363	n.d.
Mink Gulch	9,750	314	802 (2)
Montgomery Creek	1,300	41	n.d.
Morehead Creek	47,850	1,538	831 (3)
Mosquito Creek	569,000	18,295	906 (17)
Moustique Creek	90,000	2,894	890 (13)
Nelson Creek	423,600	13,620	913 (9)
New Creek	5,650	182	n.d.
Nine Mile Creek	5,000	161	n.d.
No Name Creek	16,250	523	906 (4)
Nugget Gulch	73,200	2,354	n.d.
Perkins Gulch	45,600	1,466	890 (3)
Peters Creek	53,400	1,717	n.d.
Pine (Nigger) Creek	68,450	2,201	880 (10)
Pinus (Pine) Creek	5,000	160	870 (6)
Pleasant (Little) Valley Creek (above W	17,650	568	853 (2)
Pleasant Valley Creek (below Weldon l	21,200	681	n.d.
Poquette Creek	14,750	475	802.5 (2)
Quartz Gulch (Guyet Placer)	20,550	660	854 (2)
Quesnel River (below Quesnel Forks)	477,150	15,342	830.5 (2)
Quesnel River (South Fork - above Q	3,737,800	120,187	801 (13)
Red Gulch	62,250	2,002	870 (10)
Rose Gulch	14,700	473	n.d.
Rucheon Creek (Larson Gulch)	105,550	3,394	910 (12)
Shepherd Creek	19,300	620	n.d.
Slough Creek (Ketch Benches; site 40)	198,550	6,384	907 (8)
Slough Creek (Point Benches; site 58)	733,750	23,593	915 (16)
Snowshoe Creek	433,550	13,940	n.d.
Sovereign Creek	3,000	96	n.d.
Spanish Creek	115,250	3,706	n.d.
Stevens Gulch	22,250	716	821 (1)
Stouts Gulch	485,450	15,610	906 (35)
Sugar Creek	22,900	737	798 (6)
Summit Creek	19,200	617	n.d.
Swift River	86,000	2,765	890 (1)
Terry Creek (Hixon area)	15,600	501	n.d.
Tregillus Creek	24,650	793	920 (1)
Van Winkle Creek	54,450	1,751	n.d.
Walker Gulch	12,550	403	825 (2)
Weaver Creek	10,750	345	n.d.
Weldon Creek	700	22	n.d.
Williams Creek	2,660,000	85,530	n.d.
Williams Creek (upper)	n.d.	---	822 (85)
Williams Creek (lower)	n.d.	---	850 (54)
Willow River	4,200	135	894 (1)
Wingdam Creek	200	7	n.d.
Wolf (China) Creek	47,750	1,535	n.d.
Wormwold Creek	2,450	78	910 (1)

* *Data from Holland (1950): Historical records of gold production from this period, although incomplete at many sites, are believed to be the best available and can be used as reliable minmum values. Gold production prior to 1874 when systematic record keeping began, is believed to be at least one-third of the total reported production and at many sites is much higher.*

HISTORIC GOLD PRODUCTION RANKING OF SELECTED CARIBOO PLACER AREAS, 1874-1945*

Placer Stream or Area	Grams	Ounces	Placer Stream or Area	Grams	Ounces
Quesnel River (South Fork - above Quesnel Forks)	3 737 816	120 187	Coulter Creek	31 567	1 015
Lightning Creek	3 066 522	98 602	Big Valley Creek	29 141	937
Williams Creek	2 659 983	85 530	Tregillus Creek	24 662	793
Lowhee Creek	2 302 084	74 022	Sugar Creek	22 921	737
Cedar Creek	1 175 082	37 784	Four Mile Creek	22 330	718
Keithley Creek	1 100 785	35 395	Stevens Gulch	22 268	716
Antler Creek	1 046 577	33 652	Pleasant Valley Creek (below Weldon Lake)	21 179	681
Fraser River (Prince George to Quesnel)	885 573	28 475	Quartz Gulch (Guyet Placer)	20 526	660
Lightning Creek (at Wingdam)	859 853	27 648	Shepherd Creek	19 282	620
Slough Creek (Point Benches: Site 58)	733 742	23 593	Summit Creek	19 189	617
Mosquito Creek	568 975	18 295	Pleasant (Little) Valley Creek (above Weldon Lake)	17 665	568
Fraser River (Quesnel to Williams Lake)	499 870	16 073	No Name Creek	16 265	523
Stouts Gulch	485 471	15 610	Terry Creek (Hixon area)	15 581	501
Quesnel River (below Quesnel Forks)	477 136	15 342	Poquette Creek	14 773	475
Horsefly River (Hobsons)	473 218	15 216	Rose Gulch	14 710	473
Grouse Creek	448 929	14 435	Devils Lake Creek	14 368	462
Snowshoe Creek	433 534	13 940	Barr Creek	13 622	438
Nelson Creek	423 582	13 620	French Snowshoe Creek	12 751	410
Cunningham Creek	399 853	12 857	Lawless (Half Mile) Creek	12 689	408
Cottonwood River	310 502	9 984	Walker Gulch	12 533	403
Cariboo River	258 037	8 297	Grub Gulch	11 663	375
Conklin Gulch	228 336	7 342	McMartin (Martin) Creek	11 289	363
Eight Mile Creek	217 140	6 982	Weaver Creek	10 730	345
Jack of Clubs Creek	215 088	6 916	Mink Gulch	9 765	314
Slough Creek (Ketch Benches: Site 40)	198 542	6 384	Frank (Goose) Creek	8 895	286
Burns Creek	175 871	5 655	Kangaroo Creek	8 553	275
Hixon Creek	157 397	5 061	Houseman Creek	8 273	266
Harvey Creek	119 828	3 853	Canadian Creek	6 966	224
Spanish Creek	115 257	3 706	Butcher Bench	6 718	216
French Creek	107 357	3 452	New Creek	5 660	182
Rucheon Creek (Larson Gulch)	105 553	3 394	Amador Creek	5 567	179
Moustique Creek	90 003	2 894	Nine Mile Creek	5 007	161
Swift River	85 992	2 765	Pinus (Pine) Creek	4 976	160
Lightning Creek (at Stanley)	82 384	2 649	California Gulch	4 230	136
Dragon Creek	77 688	2 498	Willow River	4 199	135
Nugget Gulch	73 209	2 354	Sovereign Creek	2 986	96
Pine(Nigger) Creek	68 451	2 201	Kong Fu Creek	2 923	94
Donovan (Poorman) Creek	60 552	1 947	Hyde Creek	2 768	89
Van Winkle Creek	54 456	1 751	Wormwold Creek	2 426	78
Peters Creek	53 399	1 717	Black Creek	1 928	62
Morehead Creek	47 832	1 538	Mary Creek	1 275	41
Wolf (China) Creek	47 739	1 535	Montgomery Creek	1 275	41
Perkins Gulch	45 593	1 466	Weldon Creek	684	22
Last Chance Creek	41 270	1 327	Little Swift River	467	15
Little Snowshoe Creek	35 796	1 151	Wingdam Creek	218	7

** Data from Holland (1950): Historical records of gold production from this period, although incomplete at many sites, are believed to be the best available and can be used as reliable minimum values. Production prior to 1874 when systematic record keeping began, is believed to be at least one-third of the total reported production and at many sites is much higher.*

APPENDIX E
GLOSSARY

A-axis: the longest axis of a clast.

Ablation: the combined processes by which a glacier loses mass; includes melting, evaporation and water and wind erosion.

Ablation till: loosely consolidated rock debris, formerly in or on a glacier, that accumulated in place as the ice was removed by ablation.

Adit: a horizontal tunnel from the surface by which a mine is entered.

Aggradation: the process of building up a surface by depositing sediment.

Allochthonous: moved a long distance from original source.

Alluvial fan: a conical deposit of sediment (usually gravel or diamicton) deposited by a stream or debris flows issuing from an elevated area onto a lowland.

Alluvium: any unconsolidated, detrital stream-deposit.

Ash: uncemented volcanic fragments less than 4 mm in diameter. Ash is the major component of tephra.

Auriferous: containing gold.

Autochthonous: transported little or no distance from original source.

Bar: a ridge or mound of unconsolidated fluvial deposits in or adjacent to the stream channel including: chute bars, developed at the mouth of a chute channel usually transverse to flow; diagonal bars, oriented oblique to river flow; longitudinal bars, aligned parallel to river flow; point bars, developed on the inside of a stream-channel bend; and transverse bars, aligned transverse to the direction of flow.

B-axis: the intermediate axis of a clast; defines clast size.

Basal till: till deposited by any process or combination of processes at the base of a glacier, including basal meltout till, lodgment till and subglacial flow-till.

Bedding: stratification or sedimentary layering where individual strata are more than 1 cm thick.

Bedload: sediments carried by the stream that are moved along the stream bed.

Bench: an elongate, narrow, horizontal or near-horizontal landform formed by differential erosion; applied most frequently to features formed in bedrock; those formed of unconsolidated sediments are usually termed terraces.

Borrow pit: a small pit from which gravel or fill has been mined.

Bottomset bed: a horizontal or gently inclined fine-grained stratum deposited in front of a prograding delta.

Boulder: a clast 256 mm or more in diameter (approx 10").

Boulder train: a line of glacially transported erratics originating from a single source. A fan-shaped distribution is termed a boulder fan.

Braided stream: a stream characterized by multiple, constantly shifting channels.

Breccia: a rock made up of strongly angular coarse fragments.

B.P.: in ^{14}C (radiocarbon) dates, refers to the number of years prior to 1950 A.D.

Cirque: a steep-walled, semicircular basin in a mountain, formed mainly by glacial erosion.

Clast: a transported sediment particle derived from pre-existing sediments or bedrock (usually refers to gravel-sized particles).

Clast-supported: a type of framework where individual clasts are in grain to grain contact supporting each other.

Clay: sediment particles less than 0.0039 mm in diameter, invariably consisting of clay minerals (a group of silicate minerals with a platy structure).

Cobble: a clast between 64 and 256 mm (2.5 to 10") in diameter.

Colluvium: sediments formed by gravity-induced or gravity-assisted movement.

Conformable: referring to strata deposited with no intervening disturbance or erosion.

Crag-and-tail: a glacially produced landform consisting of a bedrock knob (crag), and an elongate diamicton or sand deposit (tail) extending from the lee side parallel to the direction of glacial flow.

Creep: slow downslope movement of soil, rock, sediment or ice under the influence of gravity.

Cross-stratification:
strata deposited at an angle to the horizontal.

Cryoturbation:
disturbance of sediment by ground-ice or frost action.

Debris avalanche:
an unsorted, unconsolidated mass of snow, rock, sediment, ice or organic material, deposited by rapid downslope motion.

Debris flow:
viscous flow of sediment under the influence of gravity, generally with high clay and low water contents. Large particles are supported mainly by bouyancy.

Delta:
triangular shaped sedimentary deposit occurring where a stream enters a lake.

Dessication crack:
a small fissure formed by shrinkage of fine sediment during drying.

Detritus:
transported material derived from the erosion and weathering of older rock or sediment.

Diagenesis:
the process involving physical, chemical and biological changes in sediment after deposition, including compaction, cementation and recrystallization.

Diamicton:
a general term for unsorted or poorly sorted, unconsolidated clastic sediment that contains a wide range of particle sizes.

Drift:
all material deposited directly by glaciers, or as a consequence of glacial activity.

Drumlin:
an elongate hill shaped by glacial action, generally composed entirely of sediment, although some have a rock core. The long axis of a drumlin is oriented parallel to the direction of ice flow. Commonly, the lee (down-ice) slope is shallower (2-5°) than the stoss (up-ice) slope (5-10°).

Eigenvalue:
a measure of the degree of clustering around each of three vectors oriented at 90° to each other, totalling 1.00.

Englacial:
within a glacier.

Equant:
a clast having nearly equal dimensions in all directions.

Erratic:
a clast transported by glacial action which differs from the bedrock beneath it.

Esker:
an elongated sinuous ridge composed mainly of stratified sand and gravel deposited by subglacial, englacial or supraglacial streams.

Fabric:
the orientation of clasts or grains within rock.

Facies:
a category of rock or sediment defined by any key characteristics that usually reflect the origin of the unit and distinguish it from other units.

Fan delta:
a steeply dipping conical deposit of sand, gravel or diamicton formed by a combination of mass movement and fluvial processes into a lake.

Fault:
a fracture zone along which there has been displacement; includes normal (overlying block dropped relative to the underlying block), reverse (opposite of normal) and thrust (low-angle reverse) faults.

Fluidized flow:
a sediment gravity-flow in which the sediment is supported by upward-moving fluid as the grains settle.

Fluting:
an elongated glacial groove eroded into sediment or bedrock.

Foreset:
downstream (lee-side) sedimentation on a bar, dune or delta.

Geomorphology:
the study of the form of the earth and the evolution of landforms.

Glacial:
1) pertaining to glaciers; 2) a period of time characterized by extensive glacial activity.

Glacial advance:
1) the process of expansion by a glacier; 2) the interval of time during which the glacier expands.

Glacier:
a terrestrial body of ice formed by the recrystallization of snow, which is or was capable of flow under internal deformation. Alpine glacier: a glacier in a mountainous region confined by the topography (syn: valley glacier). Rock glacier: a lobe-shaped accumulation of coarse detritus with interstitial ice which exhibits slow downslope creep.

Glacigenic:
formed by glacial activity.

Glaciofluvial:
pertaining to meltwater streams flowing from glacial ice and to the associated deposits and landforms (streams, kames, eskers, outwash plains).

Glaciolacustrine:
pertaining to deposits formed in lakes in contact or affected by glacial ice or meltwaters flowing directly from glaciers.

Glaciotectonic:
referring to deformation of rock or sediment by glacial action.

Grading:
gradational changes in grain-size distribution. Normal and reverse grading signify upward decreases and increases, respectively, in grain size through a bed. Coarse-tail grading specifies grading only in the coarse fraction of a bed.

Grain:
particles, of any size, that comprise a rock or sediment.

Grain flow:
a sediment gravity-flow in which clasts are supported by direct grain-to-grain interactions.

Ground moraine:
a blanket of mixed glacial sediments (primarily tills) with low relief.

Gulch:
a steep-sided ravine or canyon with a high gradient.

Hanging valley:
a glaciated tributary valley with its floor higher than that of the trunk valley.

Highwall:
a vertical wall exposed by a mining operation.

Holocene:
the final epoch of the Quaternary, arbitrarily defined to begin at 10 000 years B.P. (syn: Recent).

Hummocky moraine:
an assemblage of hummocks, knobs and ridges of till and other sediments, interspersed with kettles, depressions, and basins frequently containing glaciolacustrine sediment.

Ice-contact sediments:
stratified material deposited directly adjacent to glacial ice, or within channels and hollows in ice. Eskers, kames and some glaciofluvial deltas are composed of ice-contact sediments.

Ice rafting:
transport of material by floating ice.

Ice sheet:
a glacier which is unconfined by topography and more than 50 000 km^2 in size. Ice cap: a glacier less than 50 000 km^2 in size. Ice field: a small ice cap and several alpine glaciers. Cordilleran ice sheet: the ice sheet that covered central British Columbia and southern Yukon during Quaternary glacial periods.

Ice-thrust features:
deformation structures, including folds and faults, and landforms, including moraines and arcuate ridges of sediment and/or bedrock, created by glaciotectonic thrusting.

Imbrication:
the preferred inclination of clasts in a sedimentary unit from which paleoflow direction can be determined. Two types of imbrication are common: a-axis of clasts oriented parallel to flow and dipping upflow [a(p)a(i)] and a-axis oriented perpendicular to flow and b-axis dipping upflow [a(t)b(i)].

Incised:
used to describe a stream which has downcut deeply through sediment or bedrock.

Interglacial:
a time of minimal glacial activity separating two episodes of extensive glacial expansion (glacials).

Interstadial:
a time separating two subordinate episodes of glacial expansion (stadials).

Intraclast:
a clast of unconsolidated sediment incorporated within a deposit.

Joint:
a fracture along which there has been no displacement.

Jökulhlaup:
a large discharge of water resulting from the sudden drainage of a glacial lake.

Kame:
a stratified deposit formed by meltwater adjacent to, within or on a glacier. Kame delta: an ice-contact delta. Kame terrace: a kame deposited between the flank of an alpine glacier and the valley wall by a glacial-side stream or system of streams.

Kettle:
a depression left as a result of the melting of a buried block of glacier ice.

Knob-and-kettle topography:
an area of irregularly undulating glacial deposits, either diamicton or sorted sediments, with the upland areas referred to as "knobs" and the depressions called "kettles".

Lacustrine:
pertaining to lakes.

Lamination:
sedimentary layers or strata less than 1 cm in thickness.

Late Wisconsinan:
the last glacial period (substage) extending from approximately 23 000 to 10 000 years ago.

Lee:
the side of an object downflow of wind, water or ice-movement direction.

Lens:
a feature (usually referring to a body of sediment) thicker in the centre than at its edges.

Levee:
a ridge or embankment of sediments built up along the sides of an overtopped channel.

Liquified flow:
a sediment gravity-flow in which the clasts are supported by the upward flow of fluid escaping between grains as the grains settle out.

Lithofacies:
categories of rock or sediment with specific physical (lithological, structural or organic) characteristics that do not incorporate genetic terminology.

Lithology:
the physical characteristics describing a rock or sediment type.

Load structures:
irregularities at the base of a stratum, commonly sand, projecting into an underlying stratum, commonly mud, caused by differential settling and compaction.

Lodgment till:
a type of basal till consisting of diamicton deposited by lodging or embedding of grains at the base of a moving glacier.

Loess:
an unconsolidated windblown deposit of silt and/or very fine sand.

Marl:
: a calcareous mixture of clay, shell fragments and calcite, formed in a lacustrine environment.

Mass movement:
: movement of material due primarily to the effects of gravity.

Matrix:
: refers to the smaller grains (usually clay, silt and sand fraction) in a sediment of mixed grain size.

Matrix-supported:
: clasts are surrounded and supported by the matrix.

Meandering stream:
: stream characterized by a single, sinuous, stable channel.

Medial moraine:
: a moraine ridge in the centre of a glacier, formed by the union of the lateral moraines of two coalescing glaciers.

Melt-out till:
: till deposited during the melting of debris-rich ice, either at the base of the glacier (basal melt-out) or on the ice surface (supraglacial melt-out).

Meltwater channel:
: channels or valleys eroded by glacial meltwater. They are commonly occupied by streams too small to have cut the valley (misfit streams).

Mineralogic:
: pertaining to minerals or mineral compositions.

Moraine:
: a landform composed of till and other sediments, deposited directly by or from a glacier at its terminus (end moraine), flank (lateral moraine) or base (ground moraine).

Nunatak:
: an unglaciated hill formerly or currently completely surrounded but not covered by glaciers.

Openwork:
: a clast-supported sediment framework with no interstitial matrix.

Outwash:
: pertaining to sediment deposited by glacial meltwater. Outwash plain: a flat, glaciofluvial surface. Pitted outwash: glaciofluvial deposits with numerous kettles, caused by the melting of trapped blocks of ice.

Overconsolidated :
: deposits (usually till) compacted beyond normal for their current depth of burial as a result of, for example, the weight of glacial ice.

Oxidation:
: the process of combination with oxygen. Oxidation (rusting) of iron minerals produces orange to red-coloured minerals such as limonite and hematite.

Paleo:
: refers to past, old or ancient (*e.g.*, paleocurrent refers to the past flow direction of an abandoned stream).

Palynology:
: the study of pollen and spores (and their dispersal and uses for paleo-environmental reconstructions).

Pebble:
: clast from 2 to 64 mm in diameter (approx 0.1 to 2.5 inches).

Peraglacial:
: pertaining to conditions created under the influence of glaciation.

Permafrost:
: any substrate in which the temperature has not exceeded 0°C for a minimum of two complete years, and in which the pore water is frozen and acts to bind or cement the substrate particles.

Planar cross-stratification:
: a set of cross-strata with a planar, lower, bounding surface.

Plano-convex:
: refers to lenses with a flat (planar) base and a convex top.

Pleistocene:
: the oldest of two epochs in the Quaternary period, characterized by extensive glacial activity extending between about 1.64 million and 10 000 years ago.

Postglacial:
: occurring after the last glaciation.

Proglacial:
: in front of a glacier.

Progradation:
: downstream or offshore advance of sediments, usually in a delta.

Push moraine:
: an end moraine formed by sediment pushed in front of a glacier.

Quaternary:
: the youngest geologic period. It is subdivided into the Pleistocene and Holocene epochs.

Recessional moraine:
: an end moraine marking a time of temporary halt of glacial retreat.

Rhythmites:
: rhythmically deposited strata, usually alternating clay, silt and/or sand.

Riffle:
: 1) a naturally occurring, shallow reach within a flowing stream. 2) a groove or ridge in a sluice box for catching gold.

Ripple bedding:
: small-scale undulating stratification produced by currents.

Sand:
: clastic grains with dimensions between 0.0625 mm and 2 mm.

Sangamon:
: the interglacial stage occurring prior to the Wisconsinan glacial extending approximately from 130 000 to 80 000 years ago.

Sedimentology:
: the study of sediments and sedimentary rocks and the processes by which they are formed.

Silt:
: clastic grains between 0.0039 mm and 0.0625 mm in diameter.

Slickensides: striated and polished surfaces formed as a result of friction along a fault.

Slide: a mass movement, usually of rock, involving motion parallel to the plane of failure without internal deformation.

Slopewash: unconsolidated material moved downslope by running water not confined to channels.

Slump: a slide, usually in unconsolidated materials, involving rotational failure along a curved surface.

Soft-sediment deformation structures: fluid escape, dish, load and pillow structures formed as a result of dewatering or loading of unconsolidated sediments.

Solifluction: the creep or slow downslope flow of saturated material under the influence of gravity.

Sorting: the degree of uniformity in grain size, ranging from well sorted, with grains all of similar dimension, to poorly sorted, with a wide range of grain sizes.

Sphericity: a measure of the ratios of the long (a-axis), intermediate (b-axis), and short (c-axis) axes of a clast.

Stoss: facing towards the direction of eolian, fluvial or glacial transport.

Stratification: the structure produced by deposition of sediments in layers (beds, laminae or lenses).

Stratigraphy: the study of the correlation, formation, composition and sequence of stratified sediments and rocks.

Stream: any body of flowing water confined to a channel. Stream types include anastomosing, braided, meandering, straight and wandering.

Striations: parallel scratches on bedrock or clasts, typically made at the base of a glacier by rocks embedded in the ice and dragged over the underlying surface.

Subaerial: formed or existing on the land surface including in streams.

Subaqueous: formed or existing in water, usually lakes or oceans.

Supraglacial till: diamicton deposited at the surface of a glacier.

Talus: debris at the base of a steep slope deposited mainly as a result of rock falls.

Tectonic: pertaining to, or designating, structures resulting from deformation of the earth's crust or the forces causing the deformation.

Tephra: all material (dominantly ash) ejected from volcanoes into the air.

Terminal moraine: an end moraine which marks the farthest advance of a glacier.

Terrace: a flat, alluvial surface, left as an elevated remnant above current stream level, due to stream down-cutting.

Terrain: a tract of land with characteristic geologic, topographic and drainage features.

Terrane: a connected series or group of rocks, with a similar tectonic or geologic history.

Tertiary: the geologic time-period immediately prior to the Quaternary, extending from approximately 66.4 to 1.64 million years ago.

Thalweg: the deepest part of a river channel.

Till: debris deposited directly by a glacier with little or no reworking by water. The common types of till include ablation, basal, deformation, englacial, flow, lee-side, lodgement, melt-out and supraglacial.

Till plain: a plain with a mantle of till; often used as a synonym for ground moraine.

Topsets: horizontally deposited strata on top of a delta.

Trough cross-stratification: a type of stratification with a trough-shaped, erosional, lower boundary.

Trunk valley: a large valley with smaller tributary valleys.

Turbulent flow: flow characterized by vortices and eddies.

Unconformity: surface, usually erosional, separating younger from older sediments or rock.

Varve: a pair of contrasting, graded glaciolacustrine laminae formed as a result of seasonal sedimentation. These form most commonly in glacial lakes as a result of meltwater inflow.

Veneer: a thin but extensive layer of sediments covering earlier deposits, but not greatly modifying the pre-existing topography.

Wisconsinan: the youngest of the four classical glacial stages in the Pleistocene. The Late Wisconsinan is approximately 10 000 to 23 000 years ago, the mid-Wisconsinan is approximately 23 000 to 65 000 years ago, and the Early Wisconsinan is approximately 65 000 to 80 000 years ago.

GLOSSARY REFERENCES

Bates, R.L. and Jackson, J.A. (1987): Glossary of Geology; *American Geological Institute*, 788 pages.

Catto, N.R. (1987): Geology 482, Geomorphology: Glacial and Periglacial Geology, Field and Laboratory Manual; unpublished report, *University of Alberta*, 215 pages.

Cormier, C. (1992): Canadian Quaternary Vocabulary, 1992; *Minister of Supply and Services Canada*, Terminology Bulletin 209, 154 pages.

Sharp, R.P. (1988): Living Ice, Understanding Glaciers and Glaciation; *Cambridge University Press*, 225 pages.