SEDIMENTOLOGICAL CONTROLS ON GOLD DISTRIBUTION IN PLEISTOCENE PLACER DEPOSITS OF THE CARIBOO MINING DISTRICT, BRITISH COLUMBIA

By Nicholas Eyles and Stephen P. Kocsis
Glaciated Basin Research Group
University of Toronto, Scarborough Campus

KEYWORDS: Economic geology, Cariboo district, placer gold, Wisconsin glaciation, older gravels, postglacial gravels, lodgement till.

INTRODUCTION

Canada produces just over 100 tonnes of gold annually from lode, base metal and placer deposits. Placer gold production accounts for about 4.5 tonnes per year with the bulk of production shared between British Columbia and Yukon. In western Canada, gold and other precious metals are recovered from a wide range of Quaternary and Tertiary sediments but the stratigraphy and origin of the deposits remains poorly understood; it is the purpose of this report to describe the geology and sedimentology of Quaternary placers on the western flanks of the Cariboo Mountains in north-central British Columbia (Figure 2-3-1). The Cariboo district is a pre-eminent gold mining area with a long history of production and excellent prospects; the total placer gold production to date is close to 3 million ounces (100 000 kilograms). Prolific gold placers occur in relatively young Pleistocene sediments (less than 125 000 years before present) including subglacial deposits that accumulated below the last Cordilleran ice sheet after 30 000 years before present. The economic concentration of gold in lodgement tills and other subglacially deposited facies is of considerable interest given the more usual tendency of ice to disperse mineralized "float" (for example, Shilts, 1976). In this paper we attempt a preliminary discussion of concentrating mechanisms that may act subglacially; an exploration model developed for the Cariboo Mining District may apply to other gold placer areas in British Columbia and Yukon.

There is a substantial, largely anecdotal history of mining in the Cariboo area but geological details are elusive. Eyles and Kocsis (1988b) provide a summary of the evoluton of mining methods up to the present day. Hydraulic mining methods, used in the past to work large low-grade deposits by sluicing, can no longer be employed given stricter environmental controls to protect the tourism and fishing industries. Modern operators must be much more selective and a more detailed appreciation of the geology, origin and likely three-dimensional distribution of the Quaternary deposits is required.

PHYSICAL SETTING AND BEDROCK GEOLOGY

The Cariboo Mining District is centred on the two historic mining communities of Wells and Barkerville. Part of the study area, centred around Likely, lies within the Quesnel Mining District. The principal gold-producing valleys have been Lightning and Williams creeks (Figures 2-3-1 and 2). The area consists of an undulating, deeply dissected plateau with mountains rising to 2100 metres above sea level. Valleys are infilled with many tens of metres of Quaternary sediments but elevations above 1700 metres are generally drift-free.

The study area lies in an area of complex bedrock geology consisting of allochthonous terranes separated by moderately to steeply east-dipping thrust faults that trend northwest. Four terranes have been recognized in the area, each with an overlapping relationship as a result of dextral accretion of crustal blocks along the western margin of North America (Price *et al.*, 1981; Jones *et al.*, 1983; Howell *et al.*, 1987). From west to east, Struik (1985, 1986) identified Quesnel, Slide Mountain, Barkerville and Cariboo terranes separated by the Eureka, Pundata and Pleasant Valley faults. The study area lies almost entirely within the Barkerville terrane Figure 2-3-1) which is composed of about 2 kilometres of Late Proterozoic and Paleozoic limestones, tuffs, turbidites, pelites, siltites, quartzites and conglomerates.

The Barkerville terrane is divided stratigraphically into the lower and upper Snowshoe Group and the Sugar limestone. The Lower Snowshoe group, comprising pelites and minor marbles, tuffs and orthoquartzites, is of Precambrian age and lies unconformably below early Paleozoic upper Snowshoe strata, in part of Mississippian age. Upper Snowshoe strata are overlain by the early Permian Sugar limestone (Struik, 1986). In the context of the present paper, the Downey Creek succession within the upper Snowshoe Group is the most significant rock unit in the Barkerville terrane because it hosts lode gold mineralization and there is a good geographic correlation between the outcrop belt of the Downey Creek succession and placer operations (Figure 2-3-2). The Downey Creek rocks trend northwest through the study area. The lode gold is associated with interbedded marble and tuffs; the rock assemblage suggests sedimentation on a continental carbonate margin subject to episodic rifting and volcanism. Preliminary sedimentological observations suggest a deep-water volcanically influenced slope dominated by turbidite sedimentation.

Lode gold occurs in two principal associations within the Downey Creek succession. In the first, native gold and tellurides occur in hydrothermal quartz veins associated with iron sulphides (Cariboo Gold Quartz mine, Wells). Secondly, at the Mosquito Creek mine, also in Wells, very fine-grained native gold occurs as films on disseminated pyrite and

British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork, 1988, Paper 1989-1.

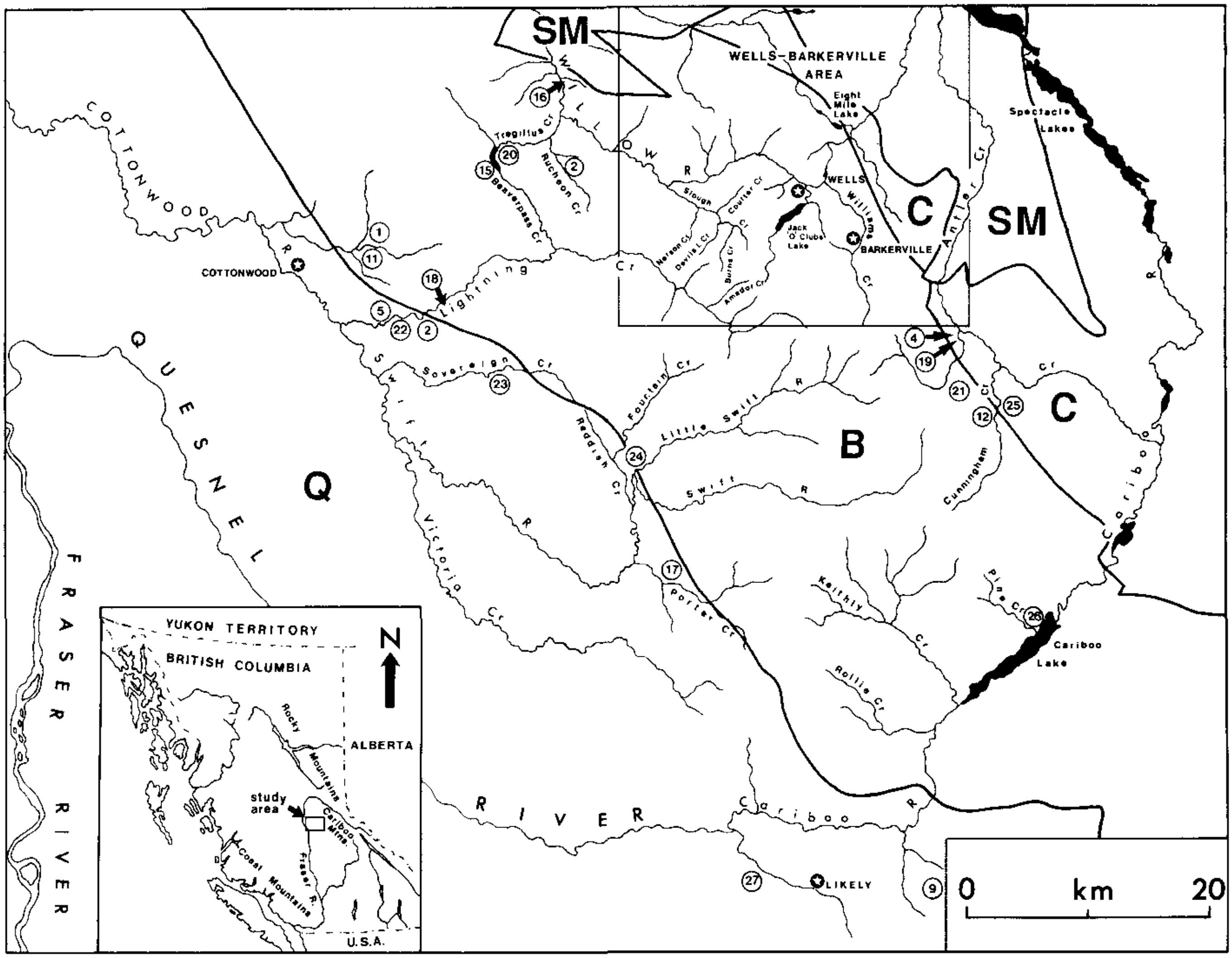

Figure 2-3-1. Location of Cariboo Mining District showing the distribution of Quesnel (Q), Barkerville (B), Slide Mountain (SM) and Cariboo (C) terranes. After Struick (1985). Numbers identify the 33 placer mines studied; mines within the Wells-Barkerville area (inside box) are shown on Figure 2-3-2. The sedimentology of placer mines 1-21 is shown on figures 2-3-4 and 5. (1) Alice Creek, (2) Lightning Creek (east of Moustique Creek), (3) Williams Creek, (4) California Gulch, (5) Lightning Creek (Lookout Point), (6) Grouse Creek (Heron Channel), (7) Eight Mile Lake, (8) Mary Creek (same as 11), (9) Spanish Mountain, (10) Eight Mile Lake, (11) Mary Creek, (12) Cunningham Creek, (13) Mount Nelson, (14) Pinus Creek, (15) Tregillus Lake (Quesnel Ready-Mix), (16) Alces Creek, (17) Porter Creek, (18) Lightning Creek (Wingdam), (19) Wolfe Creek, (20) northeast Tregillus Lake, (21) Nugget Gulch hydraulic pit, (22) Lightning Creek (west of Moustique Creek), (23) Sovereign Creek, (24) Little Swift River, (25) Cunningham Creek, (31) Devils Lake Creek, the hydraulic pits at (26) Pine Creek, (27) Bullion Pit, (28) Coulter Creek, (29) Point and (30) Ketch Benches along Slough Creek, (32) Burns Creek and (33) Fosters Ledge along upper Lightning Creek.

arsenopyrite occurring as replacement or possibly syngenetic sulphides in marble.

The precise origin of gold found in placer deposits world wide is not well constrained (Boyle, 1979; Wilson, 1984) and requires further work. Johnson and Uglow (1926) argued that deep weathering of quartz veins containing arsenopyrite and pyrite released free gold that could accumulate in crystal form as a result of supergene enrichment and this model is supported by the present study. Under conditions of deep Tertiary weathering, manganiferous siderite produced by oxidation would generate manganese dioxide which would promote gold solution transport, and sulphides could be expected to produce sulphuric acid. Placer gold varies in fineness from about 775 to 950; much gold is crystalline in the form of dodecahedrons, cubes and octahedrons, suggesting deposition from solution and limited transport. Mamillary nuggets indicating gradual accretion of gold particles are also found. Gold from each placer creek has distinct characteristics; this together with a common association with pyrite, galena and quartz, and the presence of only slightly worn crystal faces further suggests very local derivation and limited transport.

STRATIGRAPHIC SETTING OF PLACER DEPOSITS

In general, glacial and nonglacial sediments older than the last (Wisconsin) glaciation (less than 125 000 years before present) are not recognized in the Cariboo area. Older deposits and placers may be selectively preserved along buried preglacial drainage systems, an example being possibly the buried valley of the Quesnel River 4 kilometres west of Likely, where the Bullion mine (Figure 2-3-1) has produced over 3.7 million grams of gold during periodic mining over the last 100 years (Sharpe, 1939; Clague, 1987). The majority of the placers are hosted within relatively young Pleistocene sediments (less than 125 000 years before present). A generalized Pleistocene stratigraphy in the Cariboo recognizes thick lowermost gravels deposited during the lengthy cool-temperate nonglacial interval overlain by subglacial deposits from the late Wisconsin glaciation when the area was covered by westward-moving ice flowing from the Cariboo Mountains (Figure 2-3-3). Late Wisconsin glaciation was responsible for depositing extensive plugs of lodgement till and related subglacial facies along most valleys. These in turn, have been reworked or buried by postglacial (Holocene) mass-wasting and fluvial activity which has left valleyside fan deposits and terraced gravel sequences.

Figures 2-3-1 and 2 show the location of 33 placer operations that have been studied to date. What follows is a description of the sedimentology of representive preglacial, glacial and postglacial placers.

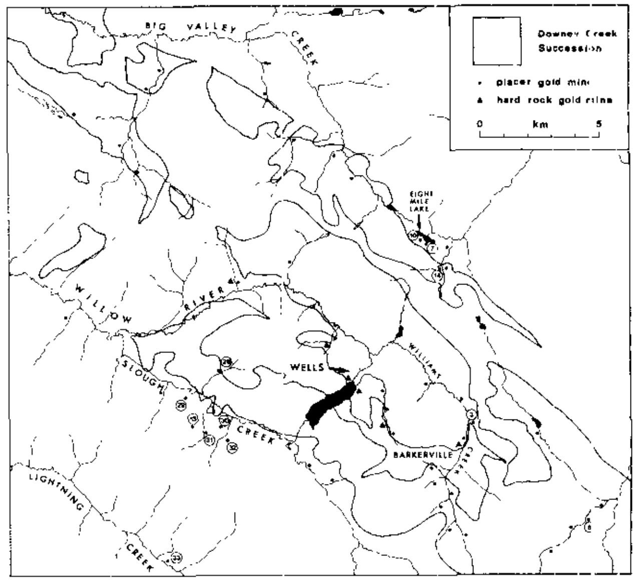

Figure 2-3-2. Distribution of the Downey Creek succession (stippled) together with placer and hardrock gold mines in the Wells-Barkerville area (Figure 2-3-1). Numbers identify location of placer operations noted in the text. Sedimentological logs from pits 1-21 are shown on Figures 2-3-4 and 5.

SEDIMENTOLOGY OF PLACER DEPOSITS

OLDER GRAVELS

Thick and extensive gravel units, truncated by Late Wisconsin glacial deposits, can be recognized throughout the study area (Figure 2-3-4). These gravels are older than 30 000 years and evidence suggests that they accumulated during a lengthy cool-temperate nonglacial interval (Clague, 1980; Clague, *et al.*, 1988; Fulton, 1984) when older glacial deposits and contained placers were extensively reworked by low-sinuosity braided rivers. These gravels, which commonly rest on bedrock as a result of a lengthy period of downcutting and reworking, are volumetrically the most important placers in the Cariboo area. They are often the most difficult to work, however, given the thickness of overburden. These gravels were, and still are, regarded as "Tertiary" by many placer miners because of their stratigraphic position below glacial sediments.

The basal, and in general the most coarse-grained gravels are the richest paying. At Alice Creek (Figure 2-3-5) gold values range from 0.52 grams per cubic metre to as high as 4.38 grams and there is a good correlation between gold values and boulder size. Gravels are weathered to a brown colour and show streaks of manganese dioxide. On the northeast margins of Tregillus Lake the highest gold values are also associated with boulder horizons within tabular beds of massive gravel that show a weak horizontal bedding. Deposition on longitudinal bars is indicated by boulder clusters suggesting frequent flood events (Brayshaw, 1984; Morison and Hein, 1987). At the Ballarat claim on Williams Creek gold grains, up to 1 gram in weight, occur within bouldery gravels recording sedimentation on the tops of longitudinal bars.

Because of the wide exposure of these preglacial gravels in placer mines, tentative paleogeographic reconstruction is possible. Braided rivers along valley floors, flanked by large valleyside fans and talus slopes, appear to have been dominant landscape elements. At California Gulch, about 7 kilometres southeast of Barkerville (Figures 2-3-1 and 2) talus 2 to 5 metres thick and consisting of crudely bedded downslope-dipping sheets of angular clasts, occurs below late Wisconsin lodgement tills. These gravels produce coarse, angular gold particals indicating local derivation, with grades averaging between 0.67 to 8.18 grams per cubic metre. These talus gravels are derived from nearby bedrock phyllites and limestones, and are representative of the "slide rocks" described by early placer miners (Johnson and Uglow, 1926).

On the western slope of Spanish Mountain, a large interstadial alluvial fan, blanketed by lodgement till, is currently exposed by placer mining. The upper surface of the fan gravels has been deformed by glacial overriding. Crudely bedded gravels dip down valley between 5 to 7 degrees and provide a profitable, low-yielding but high-volume operation. The area is well known for its good lode gold prospects and the fan may have received gold stripped from the surrounding plateau areas by cold-climate weathering processess (*see* Discussion). Two placer operations along the lower portion of Lightning Creek are working fan gravels of a similar character and genesis.

The key to the preservation of older fluvial and fan gravels below lodgement till sequences appears to be the protective role of lacustrine horizons. As ice expanded over the area during the early phases of the late Wisconsin glaciation, drainage disruption resulted in the formation of extensive ice-dammed lakes. These left a capping of fine-grained sediments over gravels (for example, Alice, Lightning and Mary creeks; Figure 2-3-5). Glacial erosion of the underlying gravels was limited, possibly because of reduced basal shear stresses at the ice base as it overrode fine-grained, saturated

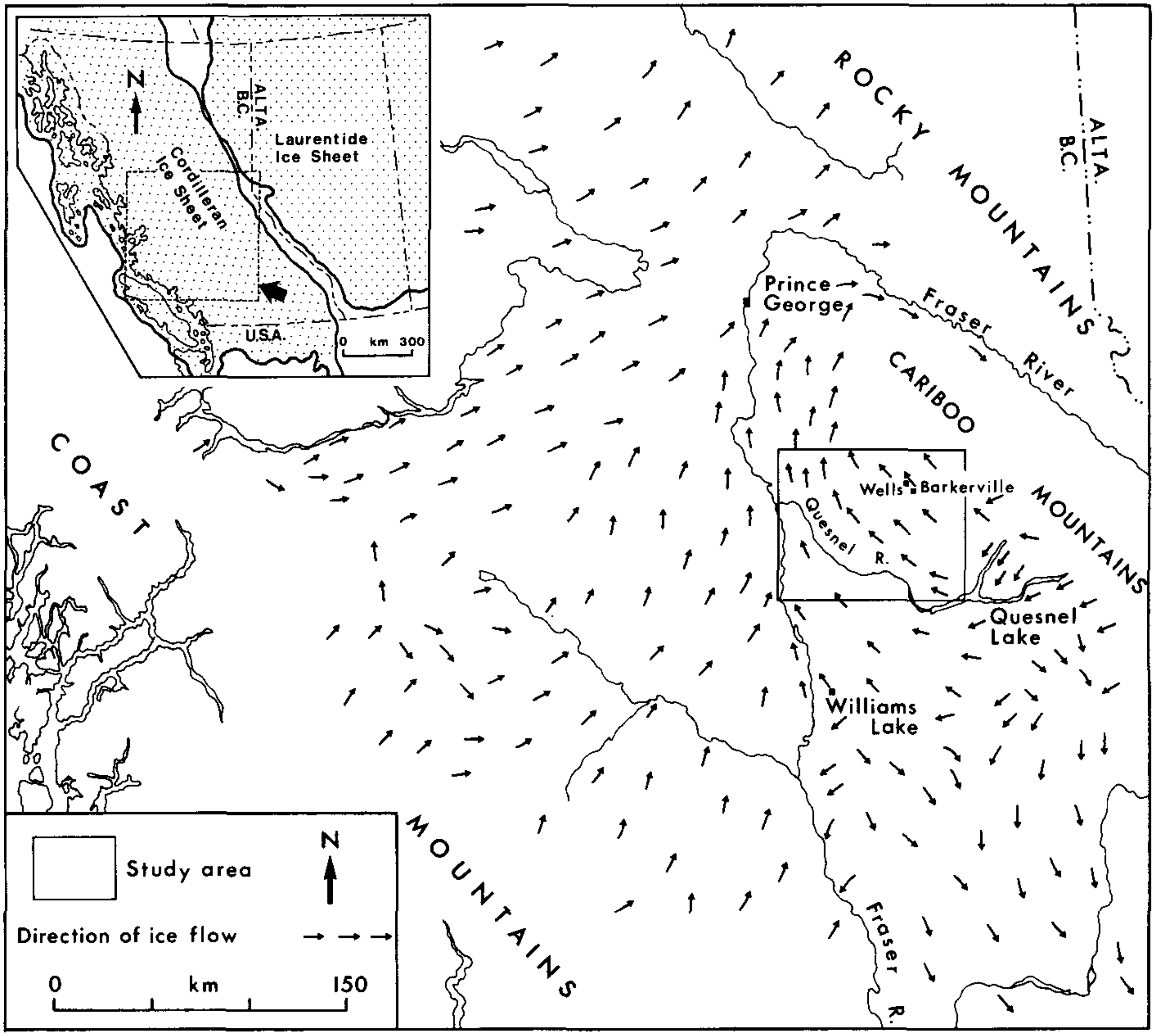

Figure 2-3-3. Ice-flow directions during the late Wisconsin (Fraser) glaciation at about 20 000 Y.B.P. After Tipper (1971).

lacustrine sediments (termed "slum" by early miners). In cases such as these, overlying subglacial lodgement tills contain uneconomic concentrations of gold and represent a major cost problem with regard to overburden excavation. In other locations late Wisconsin glaciers were able to erode into underlying auriferous gravels which contain sufficient reworked gold to be mined profitably.

SUBGLACIAL COMPLEXES

Figures 2-3-4 and 6 show the typical stratigraphic distribution and geometry of placers associated with subglacial deposits in the Cariboo Mining District. The principal subglacial placers are contained within lee-side deposits on the down-ice side of bedrock highs, the basal portions of lodgement tills, intraformational boulder pavements and channel fills, and along narrow gravel-filled notches cut by subglacial meltwaters on bedrock.

Where ice velocities are sufficiently high to allow bridging in the lee of bedrock highs or "points" as they are locally known (Johnson and Uglow, 1926), an open subglacial cavity develops (Hillefors, 1973; Boulton, 1975). Basal debris held within ice accumulates in the cavity as poorly sorted talus and is flushed by subglacial meltwaters. Subglacial fluvial reworking in cavities below the ice sheet has produced talus aprons in the lee of bedrock highs that are lucrative placer deposits. The placers are commonly draped by lodgement till deposited when the cavity was closed. The Quesnel Ready-Mix site at Tregillus Lake (Figure 2-3-5) shows evidence of multiple episodes of cavity filling and closure; overlying lodgement till has incorporated gold from the underlying gravels and can also be worked (Eyles and Kocsis, 1988b).

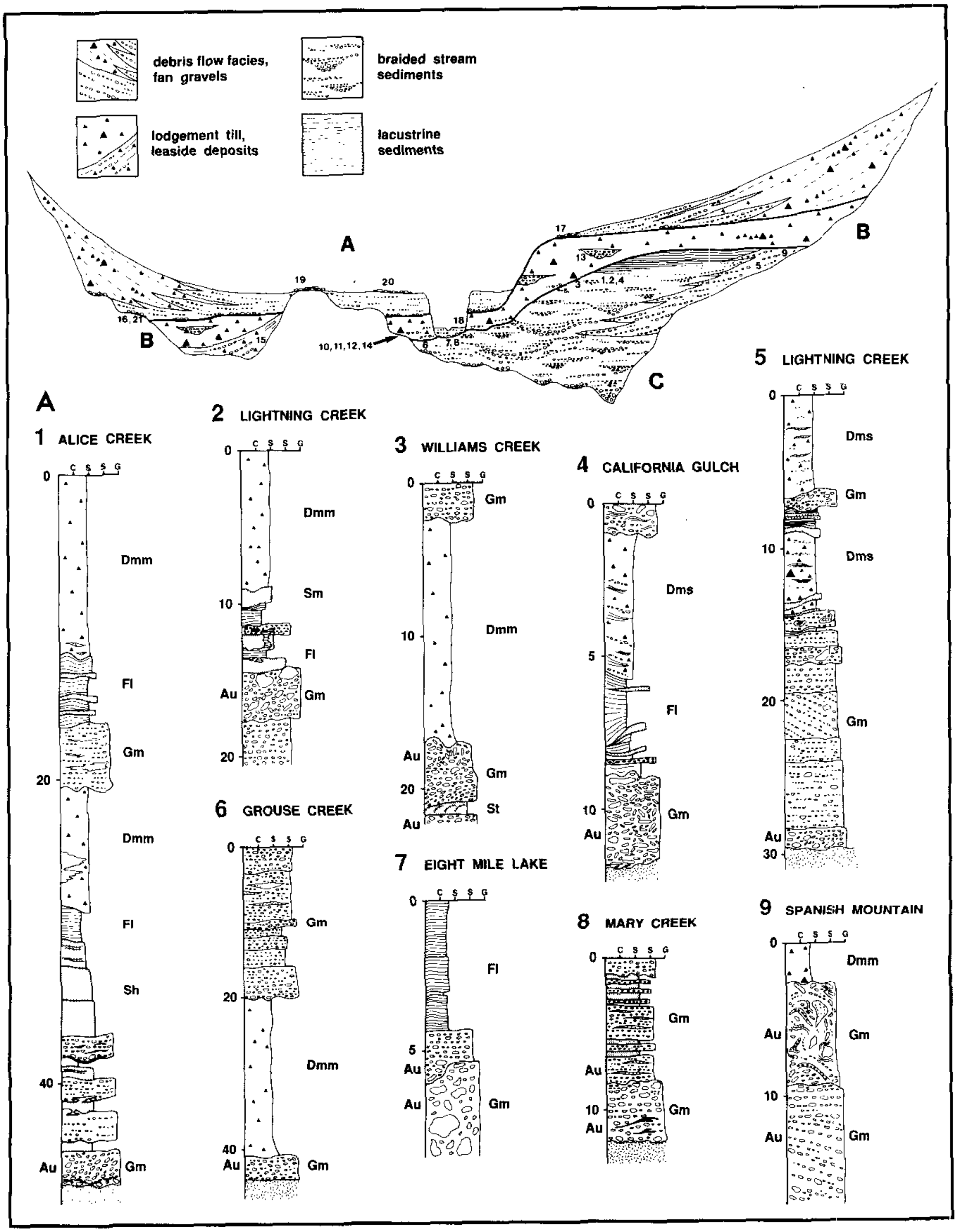

Figure 2-3-4. Stratigraphy of Cariboo gold placers;
(A) Older Gravels (older than 30 000 Y.B.P.)
(B) Subglacial deposits (30 000-10 000 Y.B.P)
(C) Postglacial gravels (<10 000 Y.B.P.)
Sedimentological logs through placer mines in Older Gravels. Number identifies locations on Figures 2-3-1 and 2.
Au identifies pay-zone.

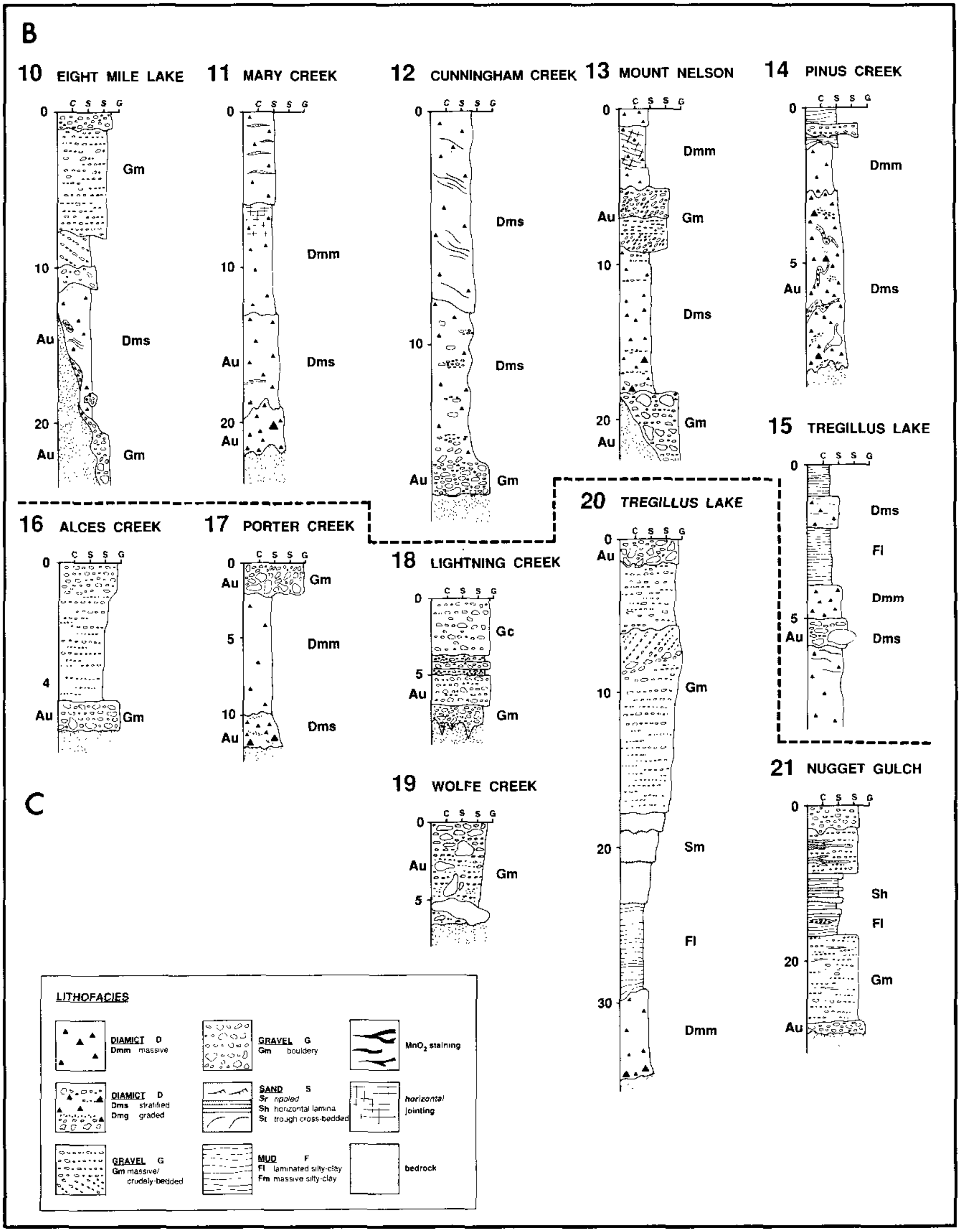

Figure 2-3-5. Sedimentological logs through placer mines working subglacial complexes (B) and postglacial gravels (C). For locations *see* Figures 2-3-1 and 2, for large-scale stratigraphy *see* Figure 2-3-4. Lithofacies code from Eyles *et al.* (1983).

Basal enrichment of lodgement tills as a result of the incorporation of interstadial gravels has been the commonest subglacial placer-forming mechanism in the Cariboo. At Pinus Creek and Eight Mile Lake (Figures 2-3-1 and 2) gold values of 1.4 grams per cubic metre are found within the basal 3 metres of lodgement till. The till shows an orange-brown colour as a result of the weathering of ankeritic limestone clasts and contains rafts of oxidized interstadial gravels. At Mount Burns, adjacent to Devils Lake Creek, gold is being worked from lodgement till resting directly on bedrock; Tyrrell (1919) describes the working of auriferous "boulder clays" at Mosquito Creek. At Mosquito Creek, recent mining operations have reported angular "crystal" gold from the lower 2 to 3 metres of lodgement till where it rests on limestones and tuffs of the Downey Creek succession; at this site these rocks contain gold values of up to 70 grams per tonne. In the Devils Lake Canyon, auriferous lodgement tills similarly rest directly on the Downey Creek succession and were worked extensively until the close of the Second World War. It is apparent that gold is not distributed evenly throughout the basal portions of lodgement tills but is often preferentially associated with intraformational pavements of aligned boulders, with long axes parallel to the ice-flow. These pavements result form the preferential lodgement of large clasts (Boulton 1975, 1982; Eyles *et al.*, 1982) and acted as a "rough bed" in and around which gold could be trapped.

Subglacial waters moving under the ice sheet deposited intraformational gravel-filled channels within lodgement tills. These have a shoestring geometry, aligned parallel to former ice flow, and record erosion and deposition by meltwater flowing on the lodgement till surface; they are genetically related to eskers and may have formed feeders to larger subglacial conduits. A placer mine on the eastern slope of Mount Nelson, 12 kilometres west of Barkerville, is currently working intraformational gravels containing nuggets as coarse as 12.8 grams. Studies of clast imbrication indicate that the channel trends north and there is a possiblity that the same channel was worked at the Point Bench some 800 metres to the north. The Point Bench site produced over 730 kilograms of gold from gravels within lodgement till, between 1906 and the early 1970s. The surrounding lodgement till away from the channel carries only marginal gold values with the exception of gravelly sections resting directly on bedrock.

Several placer operations along Cunningham Creek have mined auriferous lodgement tills. At one site, about 5 kilometres from the creek mouth, a large-volume low-yielding deposit is being worked; gold values average 0.34 grams per cubic metre and are the greatest on lowest bedrock benches as a result of proximity to older gravels along the valley floor. On the higher bedrock benches gold is too dispersed to be worked. On one bedrock bench about 1.5 kilometres further upstream, under a cover of about 20 metres of auriferous lodgement till, almost 20 kilograms of gold was recovered from a narrow bedrock channel less than 1.5 metres deep and 10 metres long. This channel forms part of a larger system cut by subglacial meltwaters under very high hydrostatic pressures. Similar notches are present on Fosters Bench at a hydraulic pit on the upper part of Lightning Creek (Figure 2-3-1).

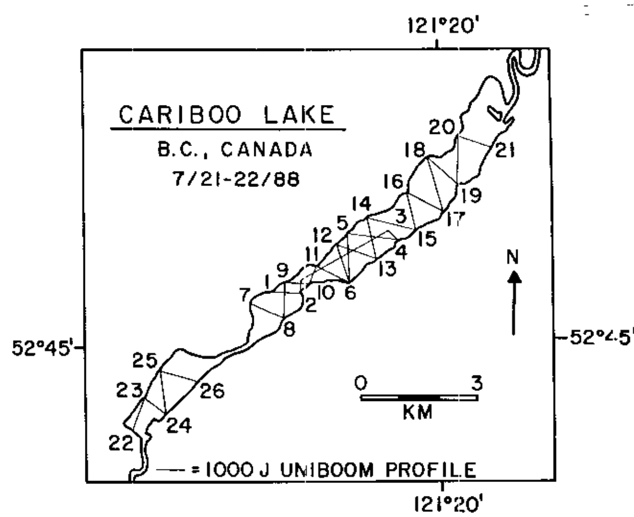

Figure 2-3-6. Cariboo Lake (Figure 2-3-1) showing location of 26 high-resolution seismic traverses.

POSTGLACIAL PLACERS

Postglacial river and fan gravels commonly form a thick valley infill obscuring subglacial and older gravel placers at depth (Figures 2-3-4 and 6). In general gold values are low, but mining costs are reduced substantially in the absence of overburden. Along several valleys, postglacial gravels extend to low elevations and can be assumed to have completely reworked pre-existing placers. In the vicinity of Tregillus Lake, along Lightning Creek, at Nugget Gulch, Porter Creek, Sovereign Creek, Alces Creek, Mary Creek and at Wolfe Creek, coarse-grained proximal outwash gravels are being worked. Gravels are very poorly sorted, contain large boulders and appreciable fine-grained matrix, and are mostly massive; clasts show an upvalley imbrication. These are typical of the deposits of longitudinal bars deposited as planar gravel sheets in shallow water. A wide range of boulder sizes suggests proximity to an active ice margin or valleyside slopes subject to mass wasting. Only minor crossbedded facies are present within multistorey gravel beds. The presence of very large (greater than 2 metres) boulders indicates frequent flood events (Brayshaw 1984; Morison and Hein, 1987). The early postglacial period saw widespread mass-wasting throughout the Cordillera (Church and Ryder, 1972; Eyles *et al.*, 1988, Eyles and Kocsis, 1988a) when large volumes of heterogeneous and often coarse-grained glacial debris derived from nearby valley sides were reworked by braided rivers along valley floors. The distal down-valley portions of these gravels are better sorted, only rarely contain "outsize" clasts and generally are uneconomic. Proximal gravels most likely result from the reworking of subglacial and older placers, and the highest gold values tend to occur toward the base of the gravel sequences. At Mary Creek, postglacial gravels show gold values averaging 0.5 gram per cubic metre where postglacial rivers erode into older gravels containing high gold values.

DISCUSSION

The data presented in this report indicate that the placer deposits of the Cariboo Mining District are restricted to three principal stratigraphic settings within late Pleistocene sediments. The so-called "Tertiary" gravels identified by earlier workers on the basis of their stratigraphic position below tills, were deposited in a long (100 000 years?) cool-temperate and nonglacial episode that terminated about 30 000 years ago. These gravel sequences are the largest by volume of the placer deposits in the Cariboo. These "older gravels" occur along valley floors for the most part buried under younger sediments, and geophysical work is needed to delineate their extent. The rivers of that time had access to older auriferous sediments and the identification of valleyside fan deposits (for example, Spanish Mountian; Figures 2-3-4 and 5) suggests that gold particles were stripped from the surrounding plateau areas by cold-climate mass-wasting processess and concentrated by braided rivers migrating across valley floors.

Paleoclimate data from mid-continent for the period 125 000 to 30 000 years ago indicates the existence of major climatic fluctuations from sub-arctic to cool-temperate. In the absence of a continuous tree-cover during colder intervals when forest tundra developed in the area, solifluction and freeze-thaw activity may have been extremely effective in breaking up bedrock and stripping supergene gold from plateau areas. It is very likely that extensive cold-climate mass-wasting at this time was much more effective in releasing large quantities of gold to the sedimentary environment than later glacial erosion which in general was highly selective. As a result, overlying subglacial placers are more geographically restricted. These deposits record the quarrying of auriferous gravels and bedrock by late Wisconsin glaciers; the basal portions of lodgement tills are good exploration targets. The upper parts of such deposits, containing more far-travelled debris, in general show low gold values and can be disregarded. Thin lodgement till sequences resting on bedrock of moderate to high relief offer the greatest potential because of the likelihood of subglacial cavity formation in the lee of bedrock knobs and the movement of subglacial waters along the lowermost portions of the valleys. Ground-based high-resolution shallow seismic work is clearly required to determine favorable sites and the ultimate extent of intraformational gravel-filled channels that occur within lodgement till (for example, Mount Nelson, Point Bench). Other locations suitable for such investigations are Cunningham Creek, Grouse Creek and Mary Creek (Figures 2-3-4 and 5).

Postglacial gravels, for the most part, do not contain the gold values associated with the older gravels and lodgement tills. Richer runs are usually an indication that the modern rivers have cut down into older placer deposits; many older placer deposits were discovered in this way.

Of critical significance is the need for large-scale, but high-resolution ground and lake-based seismic reflection surveys in order to identify the gross three-dimensional stratigraphies of the valley tills. Good placer prospects can then be identified and selectively worked. High-resolution seismic work was carried out on Cariboo Lake on a trial basis during July, 1988 in conjunction with Professor H. Mullins of Syracuse University.

Continuous seismic-reflection profiling is used to gather data on subsurface geology by emitting an acoustic pulse at regular intervals and then measuring the two-way travel time as it is reflected from physical (density/velocity) interfaces. The seismic equipment in use is an EG & G Uniboom system that operates on an electro-mechanical basis. Sound is generated approximately every second by forcing two copper plates apart that impact a rubber diaphram against the water surface. The seismic pulse emitted has a frequency spectrum range of 400 to 14 000 hertz with a dominant frequency around 1000 hertz. The uniboom was originally designed for very high-resolution (15 centimetre) work at a power output of 100 to 300 joules. At 1000 joules as much as 200 metres of substrate sediment penetration is possible while maintaining a resolution on the order of 50 centimetres. We can thus achieve sufficient penetration to define bedrock morphology as well as map seismic sequences and facies.

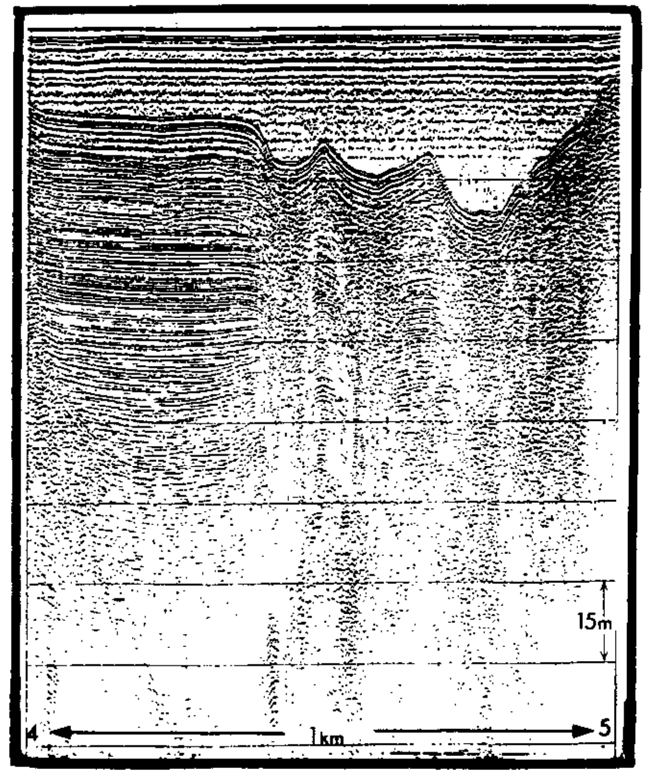

Figure 2-3-7. Seismic traverse across Cariboo Lake; for locations *see* Figure 2-3-6.

Figure 2-3-7 shows four seismic reflection profiles across Cariboo Lake which is about 1 kilometres wide. The irregular bedrock surface and the thick late Pleistocene infill up to 140 metres thick can clearly be identified. The nature of the infill and its relationship with that seen in placer mines around the lake is currently being investigated.

Detailed sedimentological modelling relating the small-scale distribution of gold within placers to subglacial and fluvial processess is also currently in progress. Given that the same late Pleistocene geologic history has probably obtained over much of British Columbia, the results of stratigraphic and sedimentological work in the Cariboo area should provide a basis for understanding the distribution of gold in other placer gold districts in province (for example, Atlin, Cassiar, Princeton and Fraser River). Figure 2-3-4 may ultimately provide the basis for an exploration model in these areas and should be tested by outcrop and seismic studies.

REFERENCES

Boulton, G.S. (1975): Processess and Patterns of Glacial Erosion, *in* Glacial Geomorphology, Publications in Geomorphology, *State University of New York,* Binghampton, pages 41-87.

——— (1982): Subglacial Processes and the Development of Glacial Bedforms, *in* Research in Glacial, Glaciofluvial and Glacio-lacustrine Systems. R. Davidson-Arnott *et al.* Editors, *Norwich Geo-Books,* pages 1-31.

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

Brayshaw, A.C. (1984): Characteristics and Origin of Cluster Bedforms in Coarse-grained Alluvial Channels, *in* Sedimentology of Gravels and Conglomerates, E.H. Koster and R.J. Steel, Editors, *Canadian Society of Petroleum Geologists,* Memoir 10, pages 77-86.

Church, M. and Ryder, J.M. (1972): Paraglacial Sedimentation: a Consideration of Fluvial Processes Conditioned by Glaciation, *Geological Society of America,* Bulletin 83, pages 3072-3095.

Clague, J.J. (1980): Late Quaternary Geology and Geochronology of British Columbia, Part I: Radiocarbon Dates, *Geological Survey of Canada,* Paper 80-13, pages 1-28.

——— (1987): A Placer Exploration Target in the Cariboo District, British Columbia, *Geological Survey of Canada,* Paper 87-1A, pages 177-180.

Clague, J.J., Easterbrook, D.J., Hughes, O.L., Mathews J.V. (1988): Was There An Ice-sheet in the Cordillera during the Early Wisconsinan? A Re-examination of the Geological Record, *Geological Society of America,* Abstracts with Programs, Volume 20, Number 7, page A4.

Eyles, N. (1983) (Editor): Glacial Geology: An Introduction for Engineers and Earth Scientists, *Pergamon Press,* 431 pages.

Eyles, N., Sladen, J.A. and Gilroy, S. (1982): A Depositional Model for Stratigraphic Complexes and Facies Superimposition in Lodgement Tills, *Boreas,* Volume 11, pages 317-333.

Eyles, N., Eyles, C.H. and Miall, A.D. (1983): Lithofacies Types and Vertical Profile Models; an Alternative Approach to the Description and Environmental Interpretation of Glacial Diamict and Diamictite Sequences, *Sedimentology,* Volume 30, pages 393-410.

Eyles, N., Eyles, C.H. and McCabe, A.M. (1988): Late Pleistocene Subaerial Debris-flow Facies of the Bow Valley, near Banff, Canadian Rocky Mountains, *Sedimentology,* Volume 35, pages 465-480.

Eyles, N. and Kocsis, S.P. (1988a): Sedimentology and Clast Fabric of a Glacially-influenced Alluvial Fan: Fraser River, British Columbia, *Sedimentary Geology,* Volume 59, pages 15-28.

Eyles, N. and Kocsis, S.P. (1988b): Gold Placers in Pleistocene Glacial Deposits; Barkerville, British Columbia, Canada, *Canadian Institute of Mining and Metallurgy,* Bulletin, Volume 81, 916, pp. 71-79.

Fulton, R.J. (1984): Quaternary Glaciation, Canadian Cordilleran; in Quaternary Stratigraphy of Canada, R.J. Fulton, Editor, *Geological Survey of Canada,* Paper 84-10, pages 39-48.

Hillefors, A. (1973): The Stratigraphy and Genesis of Stoss and Lee-side Moraines. *Geological Institute, Uppsala University,* Bulletin, Volume 5, pages 139-154.

Howell, D.G., Moore, G.W. and Wiley, T.J. (1987): Geology and Resource Potential of the Continental Margin of Western North America and adjacent Ocean Basins – Beaufort Sea to Baja, California, *Circum-Pacific Council for Energy and Mineral Resources,* Earth Sciences Series, Volume 6, pages 1-16.

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

Jones, D.L., Howel, D.G., Coney, P.J. and Monger, J.W.H. (1983): Recognition, Character and Analyses of Tectonostratigraphic Terranes, Western North America, *in* Accretionary Tectonics in the Circum-Pacific Regions. M. Hasimoto and S. Uyeda, Editors, *Tokyo, Terra,* pages 21-35.

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.

Price, R.A., Monger, J.W.H. and Muller, J.E. (1981): Cordilleran Cross-section: Calgary to Victoria. *In* Field Guides to Geology and Mineral Deposits, R.I. Thompson and D.G. Cook, Editors, Calgary 1981, *Geological Association of Canada,* pages 261-334.

Sharpe, R.F. (1939): The Bullion Hydraulic Mine, *The Miner,* Volume 12, pages 37-40.

Shilts, W.W. (1976): Glacial Till and Mineral Exploration, *Royal Society of Canada,* Special Publication 12, pages 205-224.

Struick, L.C. (1985): Thrust and Strike-slip Fault Bounding Tectonostratigraphic Terranes, Central British Columbia, Trip 14, Cordilleran Division, *Geological Survey of Canada.*

——— (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

Tipper, H.W. (1971): Multiple Glaciation in Central British Columbia, *Canadian Journal of Earth Sciences,* Volume 8; pages 743-752.

Tyrrell, J.B. (1919): Notes on the Placer Mines in the Cariboo, British Columbia, *Economic Geology,* Volume 14, pages 335-345.

Wilson, A.F. (1984): Origin of Quartz-free Nuggets and Supergene Gold found in Laterites and Soils – A Review and Some New Observations, *Australian Journal of Earth Sciences,* Volume 31, pages 303-316.

NOTES