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PLACER GOLD IN QUATERNARY GLACIOFLUVIAL AND RAISED MARINE DEPOSITS OF THE COMFORT COVE MAP AREA (NTS 2E/7)

S. Scott
Geochemistry, Geophysics and Terrain Sciences Section

ABSTRACT

Sand and gravel deposits at Birchy Bay contain anomalous concentrations of gold. The deposits to the east of Route 340 form the upper part of two delta complexes whereas the deposit to the west forms the distal bottomsets of one of these delta complexes. Another sand and gravel deposit, located south of these deltas, is interpreted to be a kame.

Preliminary geochemical analyses indicate gold is present in these sediments but not in economical quantities. Gravel lag at the base of channels, and the coarser grained massive gravel units located in the foresets of the deltas, have the highest gold concentrations.

INTRODUCTION

Placer deposits are concentrations of minerals formed by alluvial, marine, lacustrine, aeolian or glacial mechanical agents. Their formation requires a source for the minerals, a mechanism to concentrate, it and time for the mechanism to work (Boyle, 1979; Debicki, 1983). The placer potential of the near- and offshore region of Newfoundland is being examined by the Centre for Cold Ocean Resources Engineering (C-CORE) and the Bedford Institute of Oceanography (Shaw, 1992; Shaw *et al.*, 1990; Emory-Moore, 1991; Emory-Moore *et al.*, 1991). This study is of onshore placer gold potential of insular Newfoundland.

The objectives of the study were to:

1) develop a sampling strategy that would accurately evaluate placer deposits in Newfoundland, and

2) evaluate the distribution and occurrence of placer deposits, which may occur within Quaternary glaciofluvial and raised marine deposits.

Field work in 1992 was restricted to one area; this was done to enable the successful development of a sampling methodology before a comprehensive reconnaissance survey of the entire island commenced. The gravel pits in Birchy Bay were chosen because gold is preserved in them (M. Emory-Moore, personal communication, 1992) making them suitable for testing sampling procedures for their reliability, accuracy and reproducibility. The area is deemed to be one of the best sites for placer preservation in the offshore to nearshore zones (Emory-Moore and Solomon, 1989).

LOCATION, ACCESS AND PHYSIOGRAPHY

The study area lies in northeast Newfoundland in the Birchy Bay area of the Comfort Cove map area (NTS 2E/7; Figure 1). Reconnaissance surficial mapping covered the entire 1:50 000 map area. Detailed sampling occurred in the area lying between 49°15' to 49°24'N and 54°38' to 54°46'W. Access to the Birchy Bay area was via a network of logging

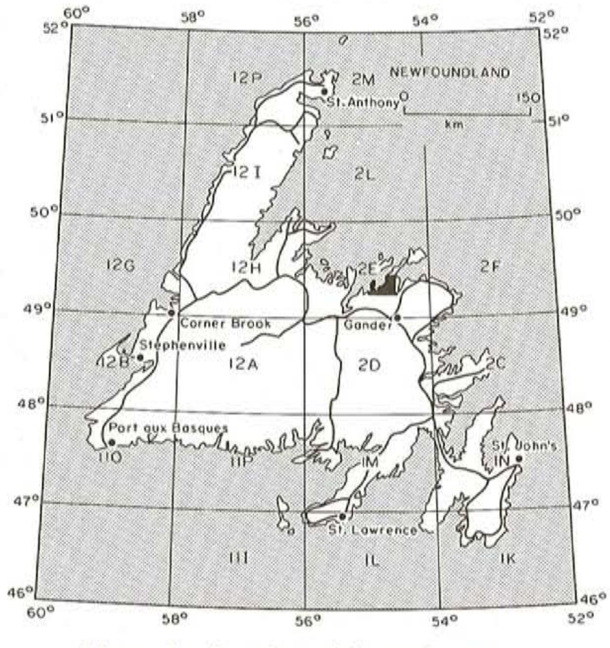

Figure 1. *Location of the study area.*

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roads. Exposures were numerous as there are many active quarries in the area.

The topography is mainly controlled by the many north–south and northeast–southwest-trending bedrock lineaments in the area, and many of the valleys and lakes follow this structural grain. The surficial cover is thin in most areas, with sand and gravel preserved in the valleys and thin till veneer over the rest of the area. The valleys are fairly shallow whereas the upland areas rise to about 75 m over most of the study area and reach a maximum of 105 m above sea level (asl) in the east. Much of the area is covered with boreal forest and extensive logging has taken place.

PREVIOUS WORK

The area contains numerous bedrock gold occurrences (Tuach, 1992; Evans, 1991, 1992) and gold is also present in sand and gravel. Lake-sediment geochemistry show anomalous values of gold in several lakes (Davenport and Nolan, 1988). Noront Resources Limited (1990) explored the area and found one gold showing just south of Horwood (Dog) Bay whereas Noranda Exploration Company Limited found three showings in the Birchy Bay area near Duder Lake (Figure 2). Evans (1991) classified the mineralization as mesothermal type, with two modes of occurrence: gabbro-hosted, gold-bearing quartz–carbonate veins accompanied by intense Fe-carbonate alteration, and sediment-hosted gold-bearing quartz–carbonate veins accompanied by silicification and carbonate alteration.

Eyles (1977) first described and interpreted glaciofluvial sediments in the Birchy Bay area but those exposures have long since been destroyed. Kirby *et al.* (1983, 1988) released granular aggregate maps of the region, which showed Birchy Bay as having extensive granular glaciofluvial material. Ricketts and McGrath (1990) did further detailed mapping of the deposits.

Emory-Moore and Solomon (1989) stated that the northeast coast of the island is suited to the formation of modern, secondary, beach or nearshore placer deposits of an allochthonous nature as it had a sea-level history of slow regression and transgression, moderate exposure on a shallow gradient and high net accumulation of sediment supply from offshore, coastal bluffs or fluvial sources.

Shaw and Forbes (1990) describe a type-B curve for the northeast coastal area. Type-B sea-level curves were predicted by Grant (1977, 1989) and Quinlan and Beaumont (1981) and indicate that following deglaciation sea level dropped to below zero and is presently rising again. Regional distributions of shell dates in the area also suggests a type-B curve (D. Liverman, personal communication, 1992). This type of curve suggests that the region is favourable to the formation and preservation of placer deposits.

Placer gold is generally preserved in coarser sediments (e.g., pebbles and boulders) although finer gold can be found in gravels and sand (Faulkner, 1986). Smith and Minter (1980) suggested that placer accumulation is more likely in areas of convergent and parallel flow as these are areas of increased sediment reworking. They also suggested that placer-mineral accumulation depends on a local source and ideal hydraulic concentration mechanisms associated with shallow turbulent flow and sediment reworking. Ideal locations for placer gold to accumulate include longitudinal, transverse and diagonal bars and channel lag deposits (Smith and Minter, 1980; Eyles and Kocsis, 1989) and downstream from channel junctions (Boggs and Baldwin, 1970). In addition, concentrations of placer gold may form at or near the bedrock interface in what is termed a 'paystreak' (Tyrrell, 1912; Boyle, 1987; Faulkner, 1986). Research on glaciofluvial placers has not been extensive as they are generally considered to be unfavourable for placer genesis (Cockfield, 1932).

SAMPLING STRATEGY AND METHODOLOGY

One of the difficulties in the evaluation of placer deposits is the sampling methodology. Before sampling for placer minerals can commence, a thorough understanding of the sedimentology of the deposit is essential. This aids in selecting the best locations for gold preservation in different environments. Once this is accomplished, samples may be taken but they must be of sufficient volume to assess the grade of the deposit. Shaowen (1987) indicated that because of uneven distribution in the gold content of placers, error exists between the gold content obtained from a limited sampling volume and the true grade of the placer. Shaowen (1987) suggested, as a result of experiments, that if the average grain size of the deposit is less than 25 mm or the boulder content is less than 14 percent then the sampling volume should be at least 0.015625 m^3 (31.25 kg). If the average grain size is greater than 55 mm or the boulder content is greater than 38 percent then the sampling volume should be 0.25 m^3 (500 kg) or greater. Samples taken for this study ranged between 0.017 and 0.077 m^3 (34 to 150 kg) and most deposits had a maximum grainsize of 25 mm of a boulder content of less than 14 percent. In this study samples $<$ or $=$ 50 kg produced a concentrate weight almost always less than 0.25 g, however, samples of 75 to 140 kg obtained sufficient heavy mineral concentrate for analysis and this weight range was used in this study. Sampling emphasized areas for best gold preservation (e.g., pebble to cobble gravel) but samples were also taken from beds less likely to preserve gold (e.g., sand and silt) so that comparisons between beds could be made.

The sampling process consisted of wet sieving the sample through a bank of six sieves having mesh sizes of 63, 31.5, 16, 8, 4 and 2 mm (Plate 1). The material washed through the 2 mm sieve mesh was processed through a Goldhound spiral concentrator until the heavy minerals were separated out (Plate 1). The heavy-mineral concentrate was then analyzed.

GEOCHEMICAL METHODS AND SAMPLE CALCULATIONS

Two geochemical methods were used to analyze samples for gold-fire assay with atomic-absorption finish and

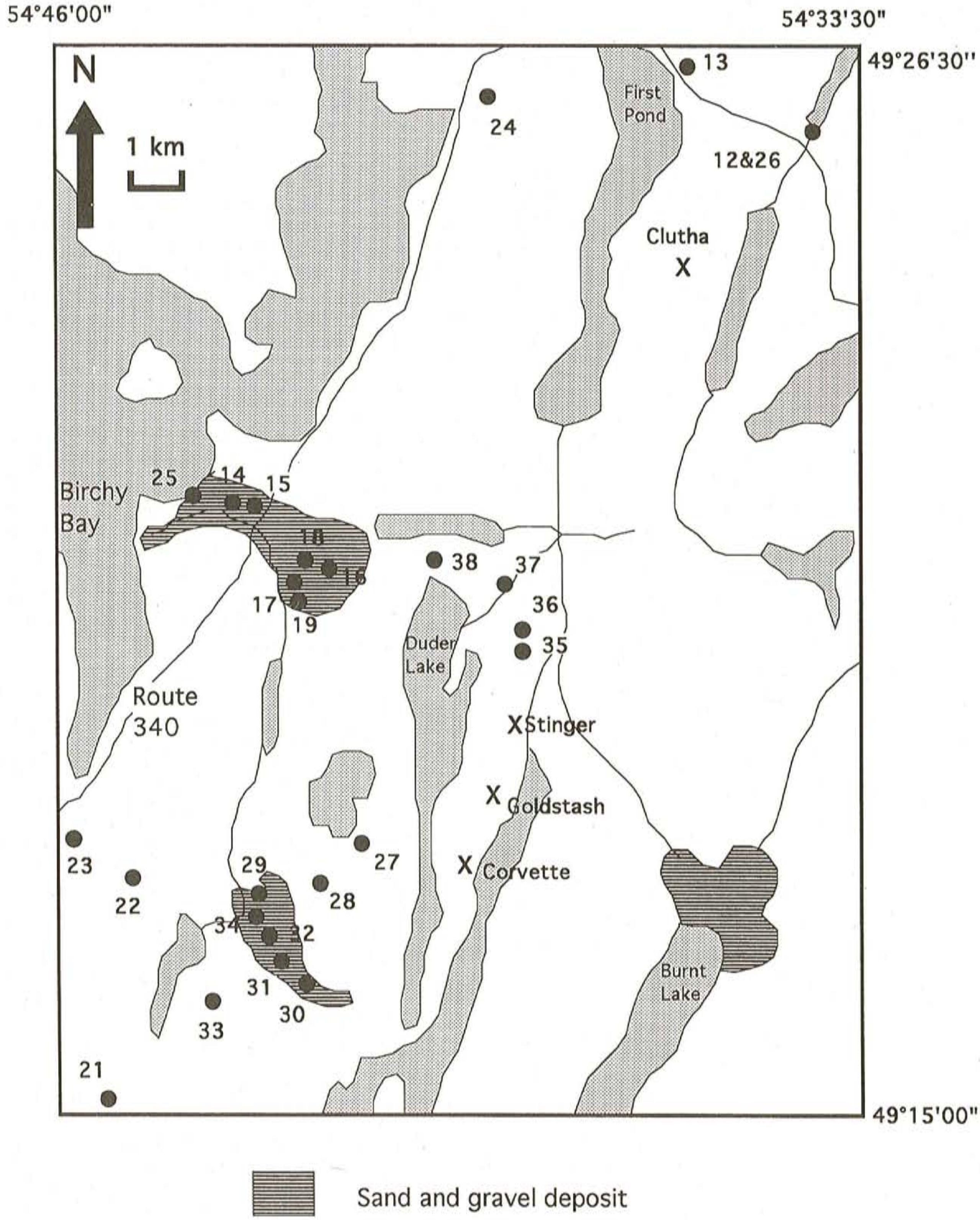

Figure 2. *Map showing the location of sites, sand and gravel deposits and gold prospects; • = site, x = prospect.*

Plate 1. *Methodology for processing a sample. A combination of sieving and Goldhounding.*

instrumental-neutron activation. The values obtained from each analytical method were obtained from concentrate. Fire assay work was performed by Eastern Analytical Limited of Springdale, Newfoundland on thirteen samples (Numbers 7011 to 7017; 7019 to 7022; 7024 and 7026, Table 1). This method gives the total gold content of the sample, which can sometimes cause difficulties due to the 'nugget effect' (Faulkner, 1986). This should not be too much of a problem because of the large initial sample size and analysis of all the concentrate. However, it was addressed by taking duplicate samples from sites for comparison.

The second method used was instrumental-neutron-activation analysis. Thirty seven samples (numbers 7023; 7025; and 7027 to 37; 7040 to 46; 7046 to 51; 7053 to 55; 7057; 7061 to 63; 7065) were sent to Becquerel Laboratories Limited, where they were geochemically analyzed (not assayed) by this method so that the sample would not be destroyed. Eight of the concentrate samples had weights < 0.2 g and for neutron-activation analysis, samples with weights < 0.2 g should be taken as semi-quantitative (Becquerel Laboratories Limited, personal communication, 1992). Six of these samples were duplicates taken to test for reproducibility of results.

Calculations for grade of deposits were made by multiplying the gold concentration by the concentrate weight(grams) and dividing by 1 by 10^9. This gave the number of grams of gold in the concentrate. This value was divided by the total sample weight to give a grams per kilogram value. By multiplying this number by 1000 a grade value of grams per tonne was obtained.

DETAILED SURVEY: BIRCHY BAY

The deposits have been grouped based on two parameters: geomorphology and sedimentology. Sites were located 1 to 2 km east and southeast of the community of Birchy Bay. One site exposed fine-grained sediment (silt and sand) and four others exposed coarse-grained material (sand and gravel). In addition, an area of sand and gravel, located south of the deposit at Birchy Bay and just northwest of Ten Mile Lake, was also sampled.

FINE-GRAINED SEDIMENTATION

Site 15

Site 15 is a section through an extensively excavated deposit 5 to 15 m thick at Birchy Bay to the west of Route 340 and covers an area 0.3 by 1 km (Figure 2). In places, bedrock is exposed at the base of the pit. The original geomorphology is unclear as most of the area is covered by houses but airphotos show a flat-topped body confined to the valley trending east to west.

The section examined at Site 15 is up to 11 m thick, exposed over 60 m laterally (Figure 3, Plate 2) and the top of the section is at an elevation of 30 m asl. It consists of three fining-upward beds; two of sand and one of silty sand. The beds dip from 4 to 8 degrees toward the west, have sharp erosional contacts and are truncated laterally by additional channel cuts (trough crossbedding). Pebbles and cobbles are rare. The sand beds are normally graded, occasionally ripple crosslaminated and contain water-escape and loading structures. Unit 6 (Figure 3) has convoluted beds, deformation structures and clasts, which deform underlying beds and are draped by overlying ones.

The series of fining-upward sequences in the strata suggests deposition by low-density turbidity currents, which in turn generated suspension settling throughout the section. The ripples present in some of these sediments indicate paleoflow was to the west and southwest. The slumps, dewatering and rapid-sedimentation structures visible here are common in subaqueous fans (Rust, 1977). The clasts, which deform and are draped by the sediment are interpreted as dropstones similar to those described by Thomas and Connell (1985). The section is located down current from, and at lower elevations than deltas identified to the east. It is part of a lower energy and finer grained system as indicated by the low-angle dip of beds and the fine-grained sediment. It is suggested that these sediments were deposited as bottomsets of the deltas seen east of the site (cf. Ashley *et al.*, 1985).

COARSE-GRAINED SEDIMENT (PROXIMAL)

Four sites in the area (14, 16, 17 and 18) are coarse grained (Figure 2). Site 14 is located 75 m west and stratigraphically below Site 15. Extensive excavation has destroyed the morphology of this site. Sites 16, 17, and 18 are located 500 m to 1 km east of Route 340 along the Horsechops woods road. These sites appear to be flat topped with sloping sides on airphotos and are confined to the east side of the north-northwest- to south-southeast-trending valley.

Table 1. Geochemical results

Site #	Sample #	Controls	Total sample wt(kg)	conc. wt(g)	Au in ppb	Grade (g/tonne)
12	7011		50	27.35	9140	0.00499958
13	7012		50	41.03	513	0.000420968
14	7013		52.55	16.43	5	1.56327E-06
14	7047		106.5	0.04	58	2.1784E-08
15	7014		50	0.04	5	0.000000004
16	7015		53.25	27.25	5	2.55869E-06
16	7016		55.55	1.15	9930	0.000205572
16	7017		63.2	0.09	5	7.12025E-09
16	7023		138.2	0.11	200000	0.00015919
16	7024		129.55	0.5	5	1.92976E-08
16	7025		139.4	0.23	42	6.9297E-08
16	7026	Lab control	28.495	28.39	42	4.18452E-05
16	7027		123	2.71	10500	0.000231341
16	7028	Duplicate of 7015	123.95	0.81	15	9.80234E-08
16	7029		74.5	1.31	52	9.14362E-07
16	7030		79.25	0.67	13	1.09905E-07
16	7031	Duplicate of 7023	97.75	1.38	200000	0.002823529
16	7037		51.15	0.02	160	6.25611E-08
16	7038		73.85	0.42	25	1.4218E-07
17	7019		50	0.15	5	0.000000015
17	7020		66.9	35.93	1924	0.001033323
17	7021		66.6	2.45	133810	0.00492244
17	7022		63.5	9.47	3070	0.000457841
17	7044	Duplicate of 7020	135.5	2.43	27500	0.000493173
17	7034		87.05	3.23	16800	0.000623366
17	7035		85.3	0.25	26	7.62016E-08
17	7036		84.95	2.01	7410	0.000175328
17	7040		129.25	0.08	600000	0.000371373
17	7041		89.6	0.4	47300	0.000211161
17	7042		114.6	0.16	300000	0.000418848
17	7043	Duplicate of 7021	147.15	2.32	56600	0.000892368
17		Lab control	0.64	0.64	1320	0.00132
17	7044	Duplicate of 7020	135.5	3.09	42100	0.000960066
18	7033		109.6	0.62	8970	5.07427E-05
18	7045		111.52	0.05	110	4.93185E-08
19	7032		85.275	0.19	25	5.57021E-08
24	7046		72.5	0.29	200000	0.0008
25	7048		89.3	0.21	44	1.03471E-07
26	7049	Duplicate of 7011	63.5	0.31	400000	0.001952756
27	7050		58.45	0.01	1800000	0.000307956
28	7051		76.2	0.01	500000	6.56168E-05
29	7053		118.7	0.07	200000	0.000117944
30	7054		117.1	0.07	130	7.77114E-08
31	7055		88.6	1.18	23	3.06321E-07
31	7055		88.6	1.24	5	6.99774E-08
32	7057		41.6	0.68	21	3.43269E-07
35	7061		67.7	0.22	84300	0.000273944
36	7062		105.95	0.33	21200	6.60311E-05
36	7063		92.8	1.38	5	7.43534E-08
38	7065		118.8	0.22	46900	8.68519E-05

* Sample numbers repeated twice are laboratory duplicates.
E stands for exponents (i.e., 10 to the power of a value)

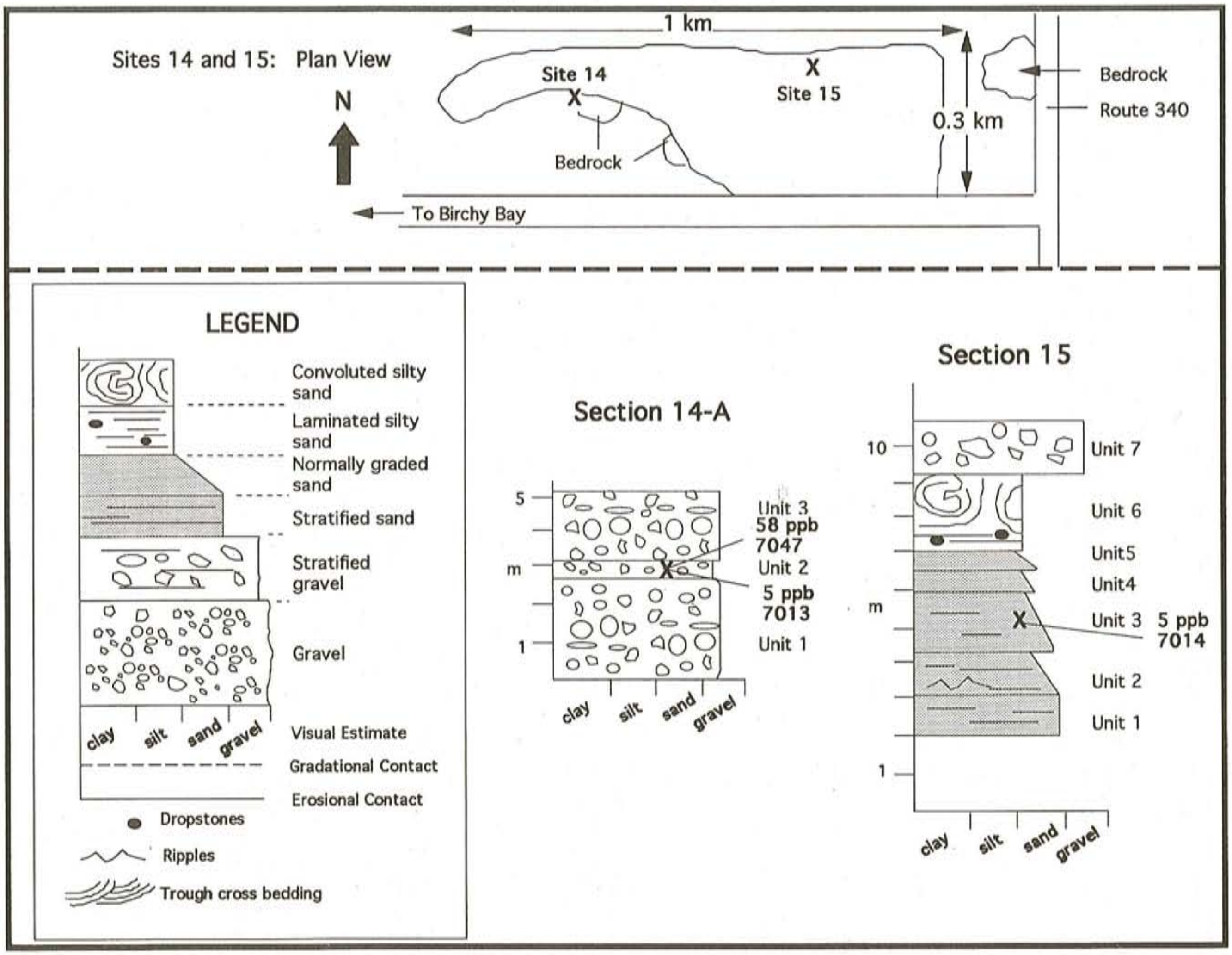

Figure 3. *Sedimentology of Sites 14 and 15; x = sample location.*

Plate 2. *Site 15: Channelized medium to coarse sand with an upper convoluted sandy silty bed. The section measures 10 m from the top to the quarry floor.*

Site 14

Section 14-A is 5.15 m thick and has a lateral exposure of over 15 m (Figure 3). The sediment abuts against bedrock on the right side of the section at a depth of 2 m. The section consists of three units with sharp contacts. The lowest unit (Unit 1) is just less than 3 m thick and consists of moderately sorted granule gravel to pebbly sand with matrix-supported pebble–cobble material composing less than 1 percent of the unit. Stratification is visible in the upper 25 cm of this unit. Overlying this is 15 to 30 cm of poorly sorted, horizontally bedded, clast-supported pebble to cobble gravel. Pebbles and cobbles tend to be clustered at the top and bottom contacts and show some imbrication. The uppermost unit consists of 2 m of poorly sorted sand and gravel with subrounded clasts ranging from 1 to 5 cm in diameter. The gravel ranges from clast to matrix supported and no structures are visible.

The beds are interpreted to have formed in a high-energy fluvial channel based on their grain size. The massive nature of the deposit, the horizontal bedding and minor clast imbrication suggest that it is part of a channel-lag deposit

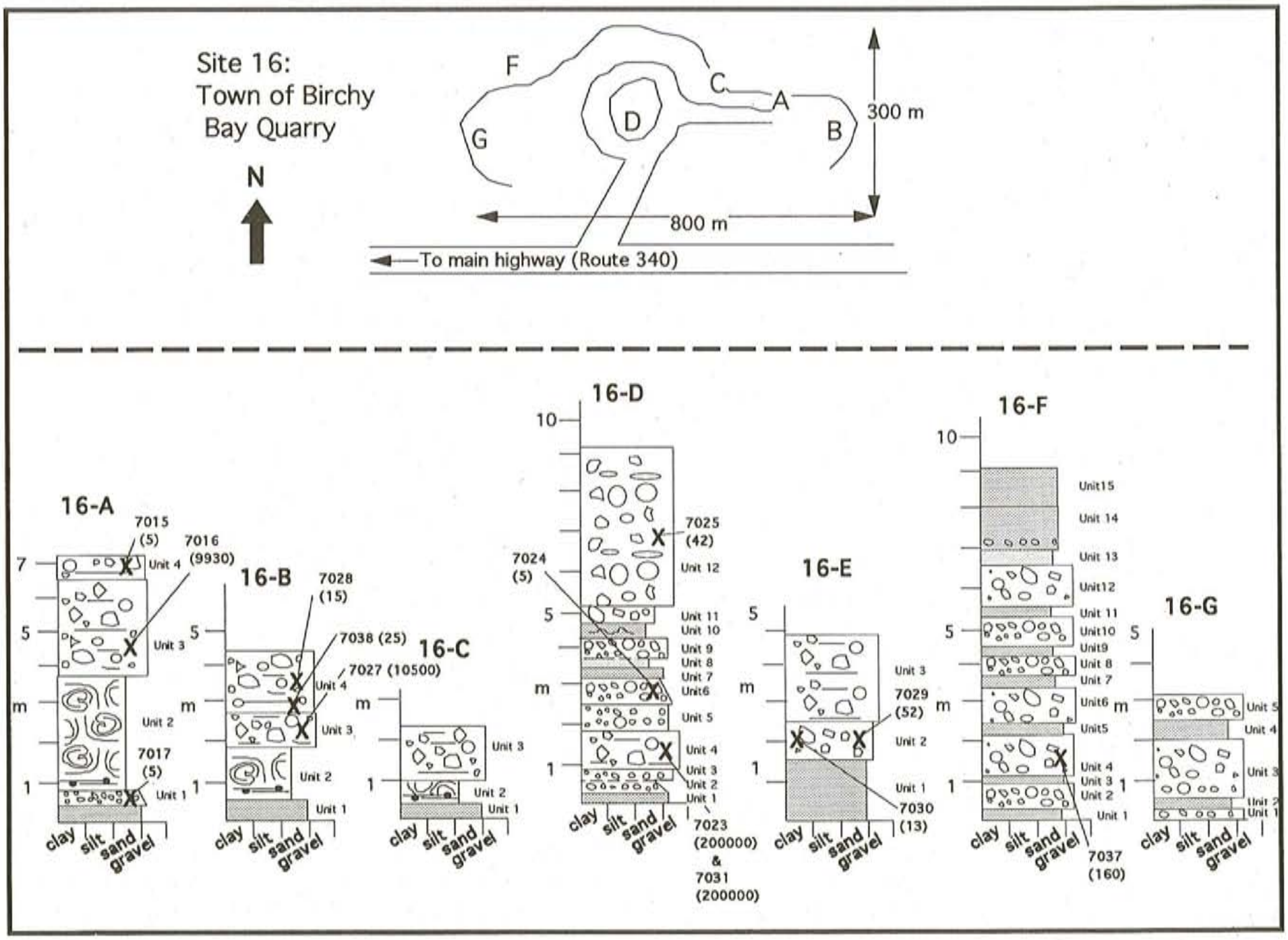

Figure 4. *Sedimentology of Site 16 (for legend, see Figure 3).*

or a longitudinal bar similar to that described by Miall (1978).

Site 16

Site 16 is located 1 km west of Route 340 and covers an area of 300 by 800 m (Figure 4). The deposit, at an elevation of 44 m asl, is up to 9.5 m thick and consists of interbedded sand and gravel with some beds of silt and clay. Seven sections were examined and sampled at this site (Figure 4) but only two will be described in detail.

Section 16-A is 7.3 m thick having a lateral exposure of 20 m. It is similar to Sections 16-B and 16-C, which occur at the same stratigraphic level. Four units of sand and gravel were defined at this site. The base of the section shows sand with interbeds of gravel, overlain sharply by laminated silty sand with convolute lamination. The upper two units consist of massive to planer-bedded granule to pebble gravel overlain by interbedded sand and gravel. Dropstones are visible in the fine-grained strata. The units in this section dip at 7 degrees to the southeast, except for the lowest unit, which dips 18 degrees to the southeast.

A wedge-shaped cast of material disrupts the upper part of the section (Plate 3). It extends from the surface to a depth

Plate 3. *Ice-wedge cast at Site 16. Penetrates to a 2.3 m depth and ranges from 5 to 40 cm wide.*

of 3 m and ranges from 5 cm to 40 cm in width. The beds on each side of the cast are pulled down slightly where the wedge was formed. Clasts inside the feature range from a random orientation in the upper and central part of the feature to vertical near the base.

Section 16-A is interpreted to show a sequence of delta foreset to topset to braided stream deposition. Unit 2 has convolute bedding and folds interpreted to be a result of downslope movement similar to features described by Allen (1984). Clasts, which deform beds and are draped by sediment, are interpreted as dropstones as they fit characteristics suggested by Thomas and Connell (1985). The upper two units show erosional contacts and channel cuts suggesting a migrating channel. This along with the changes in grain size are characteristic of braided streams (Miall, 1977; Ashley *et al.*, 1985).

The wedge-shaped feature in the upper part of Section 16-A is interpreted to be an ice-wedge cast based on criteria from Black (1976). This suggests that this surface is the original upper surface of the delta and was formed after the sediment was deposited.

Sections 16-D, E, F, and G are exposed at a lower stratigraphic level. Section 16-D is 9.1 m thick (Figure 4), has a lateral exposure of 25 m and the units all dip at 24° to the northeast (028°); twelve units are defined, mostly with sharp contacts. These units vary from 20 to 70 cm thick, and show coarse-sand to granule-gravel beds with 5 percent subrounded pebbles to 25 to 40 cm thick, massive to normally graded, clast-supported pebble- to cobble-gravel, with clasts ranging from 3 to 15 cm in diameter. Pebble to cobble beds have manganese dioxide and calcite coatings. Unit 10 consists of coarse sand with faint ripples.

Section 16-D is stratigraphically below Section 16-A. Beds dip 24 degrees or more to the northeast. The dip of the beds and the sequence of sand to coarse gravel repetitions suggest pulses of flow, which are common on the foresets of a delta (Shaw and Ashley, 1988). The ripples located in Unit 10 (Section 16-D) indicate paleoflow was to the northeast.

Site 17

Site 17 covers an area of 500 by 500 m with the maximum elevation being 41 m asl. Two representative sections will be described as they are typical (Figure 5, Plate 4). Section 17-A is 9 m thick, extends 12 m laterally and consists of eight units of sand and gravel. The base of the section shows a massive, moderately sorted pebble- to cobble-gravel overlain by coarse sand with trough-crossbeds, climbing ripples and reverse faulting, which extend into the convoluted coarse sand above. Overlying this is a massive, poorly sorted pebble- to cobble-gravel with a matrix of coarse sand to granule gravel and clasts that are slightly cemented by a calcite coating. This is overlain by a massive well-sorted coarse sand. Above this are three units of massive, poorly sorted, pebble- to cobble-gravel with some imbricated clasts and alternating layers of pea gravel, coarse gravel and pebbly sandy gravel.

Section 17-C consists of eight beds of sand and gravel. The section is 6.65 m thick and has a lateral exposure of 25 m. The beds dip at 22 degrees to the north-northwest. The beds range from 60 cm to 2.5 m in thickness and are made up of massive to normal or reversed graded, moderately sorted pebble- to cobble-gravel. Clasts range from 1 to 10 cm in diameter with an average diameter of 3.5 cm.

The sediments at Site 17 show features typical of foresets of a Gilbert-style delta: coarse grain size, moderately dipping beds (22 to 26 degrees) and alternating fining- and coarsening-upward beds (Shaw and Ashley, 1988). Section 17-A, Units 1 to 3, show a progression from coarse-grained gravel at the base, up through trough crossbedding, and into thin flat sand laminae that then passes up into climbing ripple laminations that are draped by a silt—clay coating. These ripples indicate paleoflow is to the northwest and this sequence is interpreted to be one with waning flow. The faulting at Site 17 is syndepositional and suggests deposition over buried ice. The style of faulting and the flat-bedded upper units suggest that buried ice melted and caused the faulting, while rapid deposition continued on the surface. Similar features are described by Eyles (1977), which suggest switching of depositional channels in the delta.

Site 18

At Site 18, three sections were examined but only one will be described here as it is representative of the other sections (Figure 6). Section 18-A is 4.72 m thick, has a lateral exposure of 12 m and the elevation of its top surface is 41 m asl. It has nine units, some of which dip 22 degrees to the northeast. Channels are visible with trough crossbeds indicating paleoflow was northwest (280°). The units consist of massive, poorly to moderately sorted, clast- to matrix-supported, granule to cobble-gravel (with some clast imbrication) or massive medium to coarse sand.

The three sections at Site 18 are interpreted as foresets of ice-proximal deltas. The sections have steep dips and consist of coarse-grained material that Shaw and Ashley (1988) suggested are indicative of deltas.

OTHER SAND AND GRAVEL SITE

The other major deposit of sand and gravel examined in this study is located at the southwest end of Duder Lake. The deposit is 3 km long, 0.2 km wide and is up to 6 m thick (Figure 2). Five backhoe pits were dug in this deposit (Sites 29, 30, 31, 32, and 34).

The deposit consists of bedded, well-sorted, fine to medium sand and moderately to poorly sorted open-work, cobble- to pebble-gravel. The beds dip from 18 to 38° and range from 20 cm to 1.2 m thick. Some beds are massive whereas others show fining-upward sequences, imbricated clasts and gravel lags.

This deposit does not have the morphology of a deltaic deposit although the grain size and the dip of the beds suggest

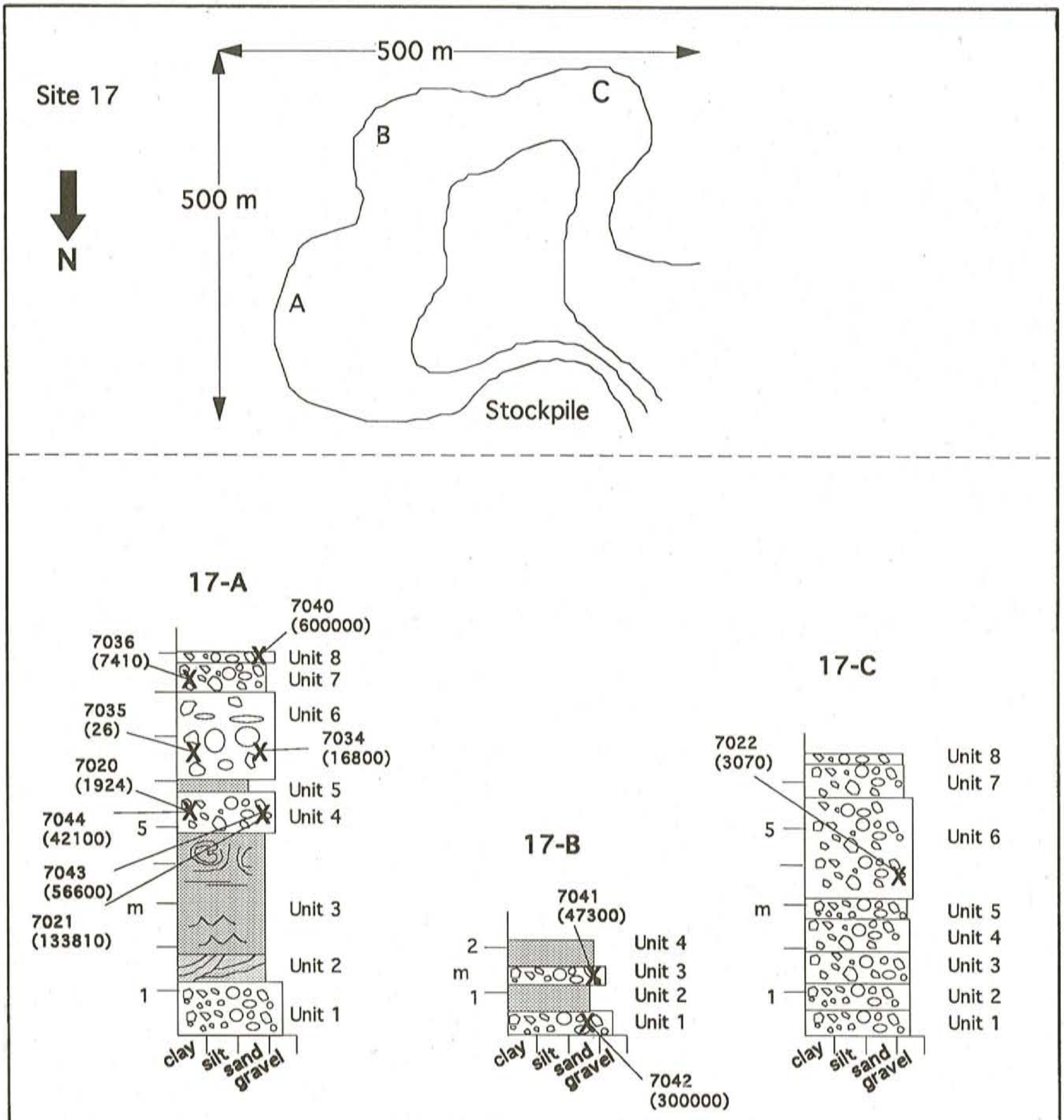

Figure 5. *Sedimentology of Site 17 (for legend, see Figure 3).*

a deltaic origin. The material in the deposit has characteristics of deposition in flowing water, including imbricated clasts, the sorted nature of the sediment and the abundance of rounded clasts. Sugden and John (1976) suggested these features are found in kames.

DISCUSSION

The sites described can be used to develop a geological history for the area. Following deglaciation sea level dropped, forming at least two sea-level stands, one at 44 m asl and another at 40 to 41 m asl, where Gilbert-style delta complexes were developed. The sections at Site 16 dissect the topsets and foresets of a Gilbert-style delta, which was formed when sea level was at 44 m asl. Flow indicators suggest a source southwest to west of the deposit yet the material extends for only 800 m west and then the surface drops to 40 to 41 m

Plate 4. *Site 17: Section 17-A is 9 m thick from the quarry floor to the top. The best gold preservation occurs in the area indicated by the arrows.*

asl (the top of Sites 17 and 18). This suggests the material at Site 16 was eroded as sea level continued to drop. The sediments at Sites 17 and 18 also show features typical of foresets of Gilbert-style deltas. Paleoflow indicators from these sites indicate flow came from the east or southeast. The flow changed and the flat-topped nature of the sediment indicate that these deposits are not linked to Site 16. Both Sites 17 and 18 have an expanse of sand and gravel extending south, which shows channels on the surface, suggesting that an outwash system fed the delta. It is possible that the deposits formed during the second sea-level stand of 40 to 41 m asl reworked sediment from Site 16. As the sea level continued to drop, the bottomset deposits of one of these deltas was exposed at Site 15. It is likely that this sediment is associated with the highest delta complex and that the bottomset beds for the lower elevation delta are not yet exposed.

The sediment at Site 14 may have been deposited in a proximal position to the ice and the sediment at Site 15 was then deposited over it later. However, it is more likely that the material constitutes part of a channel deposit, which formed as ice-proximal deposits to the east were forming.

GEOCHEMICAL RESULTS

The geochemical results show that gold is common in these sediments (Table 1). The values shown on Table 1 are from extreme concentrates of large samples (i.e., 0.01 to 2.32 grams from 58.45 to 147.15 kg; this means that the gold values have to be diluted by the amount of material processed to obtain the original grade of the sample). Calculations of grade (taking concentration into account) are shown in Table 1.

Sample 7014, Site 15, Unit 3 has a gold value of 5 ppb. The sediment is distal from the source of flow and is not expected to contain high gold values. As mentioned earlier, gold values for placers should be higher in coarse-grained, proximal sediment.

Samples obtained from Site 14 contain gold values of 5 and 58 ppb. A second sample was taken here because the material met some of the criteria (coarse grained; possible paystreak zone) for having higher gold values (Herial *et al.*, 1989). The sediment was interpreted to be part of a longitudinal bar (another likely zone for placer gold preservation) but because these samples did not come from the lowest bed it is possible that more gold may accumulate in the sediment below.

At Section 16-A, Unit 1, the gold value is 5 ppb. Units 3 and 4 have values of 9,930 and 5 ppb, respectively. Section 16-B, Units 3 and 4 have gold values of 10,500 and 15 to 25 ppb. These sections were correlated as being synchronous, based on sedimentology, and the derived gold values support this correlation. The highest gold values in this section are from the stratified sandy pebble- to cobble-gravel (Unit 3). Section 16-D had samples taken from three units; Unit 4 had values of 200,000 ppb for two samples and Units 6 and 12 had values of 5 and 42 ppb, respectively. These three units are composed of coarse-grained pebble- to cobble-gravel but only Unit 4 does not fine upward, is mostly clast supported and contains clasts ranging from 2 to 15 cm in diameter.

At Section 17-A, six samples were analyzed for their gold content. Section 17-A, Unit 4 has values ranging from 1924 to 133,810 ppb, Unit 6 ranges from 26 to 16,800 ppb, Unit 7 measures 7,410 ppb and Unit 8 has a value of 600,000 ppb. Analysis of samples from correlated units in a section 3 m east had values of 300,000 ppb for Unit 1 and 47,300 ppb for Unit 4. The gold values from Section 17-C, Unit 6 ranged from 3,070 to 27,500 ppb. The highest gold values came from the units consisting of poorly sorted, matrix-supported, pebble- to cobble-gravel with clasts ranging from 2 to 70 cm and with an average size of 35 cm. At Section 18-A, the gold value in Unit 6 was 110 ppb. This unit was sampled as it had similar characteristics to units at Site 17.

Gold values in the kame deposit ranged from 5 to 200,000 ppb. The higher gold values came from the coarser grained pebble to cobble beds that show evidence of reworking. Lower values were obtained from the sandy beds.

DISCUSSION

These data enable relation of gold values to grain size and sedimentology of the deposits. In general, the higher gold values came from the coarser grained, massive gravels with an average clast diameter of 7 to 35 cm, and from gravel lags at the base of channels. This type of gravel was found in the foreset beds of the Gilbert-style deltas. The higher values seem to also occur in areas where reworking of sediment occurred. Duplicate samples taken from some of the beds indicate that results were reproducible. However, the gold values can vary in a single unit demonstrating the difficulty in evaluating a placer deposit due to variability in gold distribution or deposition. Consistent high values were obtained, compared to the background, and this suggests that some units contained anomalous gold contents.

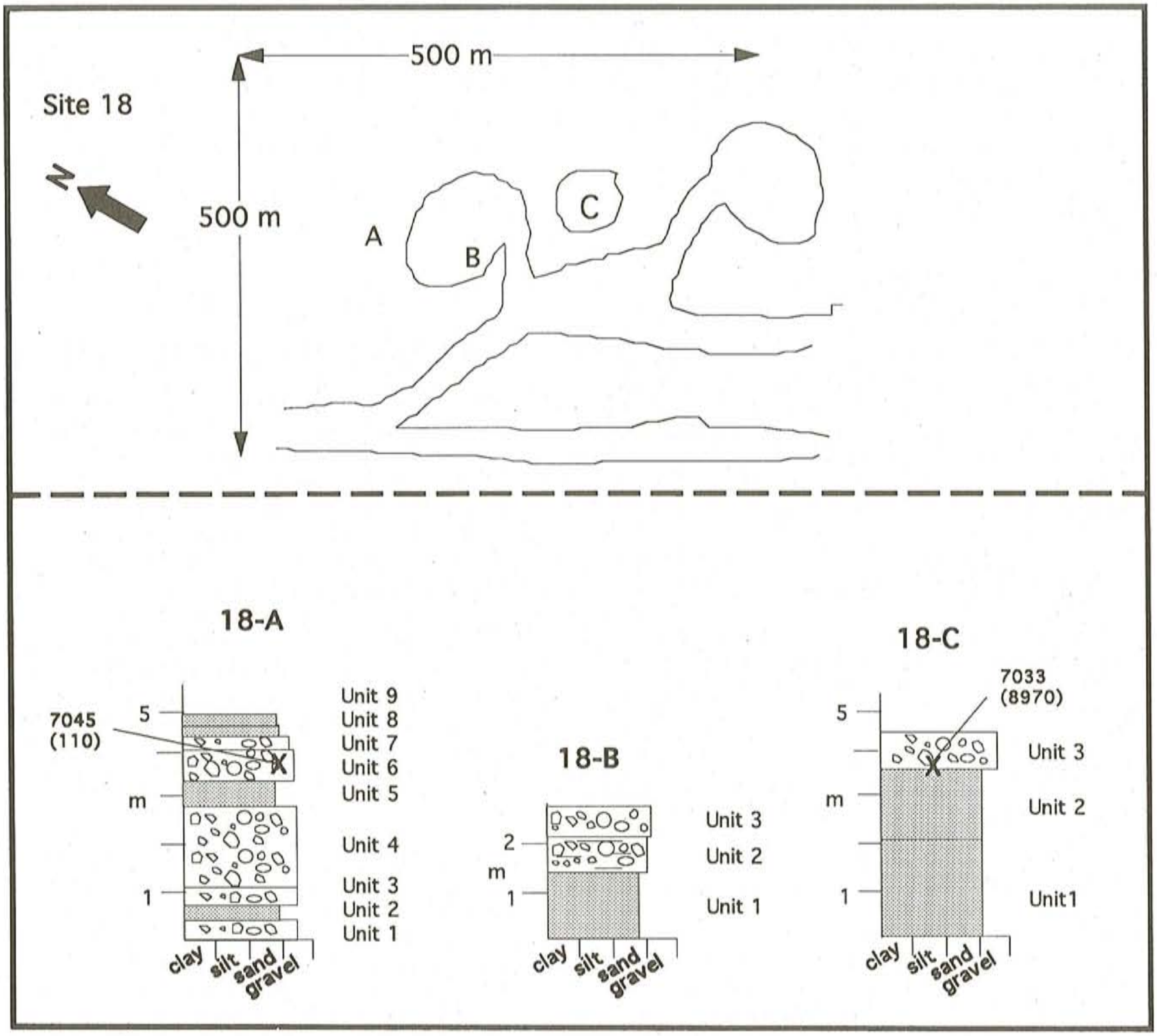

Figure 6. *Sedimentology of Site 18 (for legend, see Figure 3).*

These deposits may not have had a sufficient amount of time to allow for reworking of material and concentration of gold (cf. Debicki, 1983). Since deglaciation between 14,000 to 13,000 years BP, sea level dropped from +44 m asl to its present level by 12,000 to 10,000 years BP (Shaw and Forbes, 1990), therefore, this area had a period of only 2,000 to 4,000 years for stream flow or current to rework and winnow the gold. Fluvial placers in British Columbia are formed in material deposited during interglacial or preglacial times 125,000 to 30,000 years BP (Eyles and Kocsis, 1989). These deposits have undergone an extensive period of reworking to concentrate the gold. The absence of interglacial or preglacial gravels on the Island of Newfoundland suggests that the other placer deposits will have similar geological histories.

Calculations indicate grades in these deposits range from 7.12 by 10^{-9} to 0.0049 g/t. The lower values were obtained from sections that were not expected to contain much gold and were used as controls, but in some cases, beds that fit criteria for gold preservation also had low values. Break-even placer operations in British Columbia can operate at 0.5 g/t (based on a gold price of US $375/oz), (V. Levson, personal communication, Ministry of Energy, Mines and Petroleum Resources, Geological Survey Branch, British Columbia, 1992). This figure varies with the type of deposit, thickness of overburden and location. The results obtained from this study suggest that the deposit is not economic as a placer operation by itself. It is possible that gold may be recovered as a by-product to gravel operations. Lehrberger and Irber (1991) indicate that very fine-grained gold is recovered from gravel operations in Germany. Gold is upgraded by the sizing and cleaning process involved in the operations, so much so that the gold content in the natural gravel may only be 0.001

Table 2. Dimensions of the sand and gravel deposits

Site #	Deposit Type	Area (meters²)	Thickness (m)	Volume (meters³)	Reserves (grams)
14 & 15	delta bottomsets	300000	15	4500000	1.8
16	delta	640000	10	6400000	324.48
17 & 18	delta	250000	15	3750000	5594.00
29 to 34	kame	60000	5	300000	15.86

Note: Thickness is a minimum value.

g/t, yet after processing it is upgraded to 1 g/t. Based on a marginal cost basis, the authors indicated that a cut-off grade of 0.035 to 0.05 ppm was yielded at a gold price of $500 U.S./ounce. Because many of the quarries in the Birchy Bay area have heavy equipment in use, it may be economical to build a sluice and run the gravel through it in an effort to recover the gold.

DEPOSIT DIMENSIONS, RESERVES AND TRACING THE GOLD TO ITS SOURCE

The dimensions of the glaciofluvial deposits discussed above are shown in Table 2. Ricketts (1990) presented volume estimates of these deposits for all the gravel in the area including areas upon which houses are built. The volume estimates in Table 2 reflect the gravel available for use. These volume estimates are minimum values based on observations. For example, the thickness of each deposit was determined to be the thickness from the quarry floor to the top. The actual material depth is unknown at this stage but could be determined with some hammer seismic work or drilling. Calculation of reserves is shown in the last column. These are based on the excavation of all material in the deposit. There are approximately 2 t in 1 m³ of material (F. Kirby, personal communication, Department of Mines and Energy, 1992). At Site 17, there are 7.5 by 10^6 t of material with an average grade of 0.00074 g/t. Therefore, the total reserves would be 5,594 grams of gold.

To find the source of the gold in these deposits more work must be done. However, based on the relationship of ice flow (north and northwest), glaciofluvial gravels having flow indicators suggesting a source to the southeast and gold prospects to the east and south, it is likely that the source for gold in the material at Birchy Bay is somewhere to the southeast or east. Two methods that help determine sources are morphology and chemistry of the gold grains. Some of the concentrate samples taken during this study were examined with a binocular microscope. The morphology of the gold grains in these samples were all similar, the grains being irregular and abraded. According to Yeend (1975) the degree of morphological change to gold grains in a fluvial environment increases as bedload size and flow rate increase. Additional work on gold-grain morphology is planned once samples are returned from laboratory geochemical analysis. In addition, scanning electron microscope and electron microprobe work are planned. The geochemical signature of the gold grain can also indicate possible sources.

SUMMARY AND CONCLUSIONS

The work completed to date indicates that gold is common in the Birchy Bay glaciofluvial deposit, but low gold concentrations suggest further exploration is probably not warranted. Much of the sand and gravel is either in use as farmland, taken up by residential buildings or has been substantially excavated. The deposits are young and insufficient reworking has taken place for the gold to concentrate to economic grades suitable for solely placer mining. However, it may be feasibe to operate as a sideline to existing aggregate operations. The sand and gravel deposits consist of two areas of proximal deltaic, one area of distal glaciofluvial deposition and an area of kame deposition. Highest gold concentrations are in the lag gravels and in the coarse-grained massive gravels having average clasts of 7 to 35 cm diameter, which typically occur in the foresets of the deltas.

The sampling strategy developed is an effective method of assessing gold concentrations in glaciofluvial sediments. Geochemical analysis indicates that results are reproducible for samples. The calculations of grade made using this data are crude considering the amount of material processed for the area. To gain a more accurate idea of volume of material involved, drilling or hammer seismic work needs to be performed.

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