INTEGRATED DRIFT EXPLORATION STUDIES ON NORTHERN VANCOUVER ISLAND (92L)

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INTRODUCTION

Recent geoscience research by the British Columbia Geological Survey Branch (BCGS) on northern Vancouver Island has examined parts or all of map sheets 92L/5, 6(W), 11(W), 12 and 102I/9 (Figure 1). The objectives and results of these integrated have been well summarized (Panteleyev *et al.*, 1994) and detailed in a series of discipline specific publications (*e.g.* Nixon *et al.*, 1994; Sibbick and Laurus, 1995, this volume). With respect to the drift exploration program, studies to date have concentrated on the collection of till geochemistry data and generation of newsurficial geology maps at a scale of 1:50 000 (Huntley and Bobrowsky, 1995, this volume). In addition, cooperative drift exploration studies were begun in 1994, involving federal and university scientists. This paper provides an outline of the activities and preliminary results of the geophysical and drilling surveys completed this year at several locations in the larger study area (Figure 2).

The broader intent of the cooperative research centres on developing and testing techniques which will assist mineral explorationists in dealing with a complex overburden cover. A number of widely used methods were focused on three target areas to address the following objectives:

- Develop, contrast and evaluate techniques for determining overburden thickness.
- Establish and refine methodologies for interpreting the stratigraphy and sedimentology of buried unconsolidated sediments.
- Explore and assess the potential for utilizing geophysical and geochemical techniques in the recognition and identification of buried bedrock.

The methods of subsurface evaluation used for this cooperative study include mud rotary drilling, flight auger drilling, gravity surveying, magnetometer surveying, electromagnetic (EM) surveying, seismic profiling, till geochemistry and biogeochemistry.

Several criteria support the selection of the three study sites chosen. Site 1 (Rupert Main) is an area known to be covered by a thick blanket of unconsolidated sediment (Figures 2 and 3). This site was viewed as the best to establish methods for evaluating drift thickness. The subdued, low-relief topography and recently logged surface were important factors in the application of geophysical techniques such as EM. Existing diamond-drillhole data ensured selection of a thick section for our drilling. The potential for encountering exceptionally thick overburden (215 m; Bobrowsky and Meldrum, 1994) would result in the longest stratigraphic record ever recovered in the region. The area is of potential economic interest, although little is known of the bedrock geology because of the thick and extensive surficial cover. Finally, the eastward extension of the Holberg fault runs through this area. Given the above, four transect legs were laid out in site 1 (Figure 3). Site 2 (View Point road) is a well mapped region (1:2400-scale bedrock data), where diamond drilling data are extensive and overburden is relatively thin and of constant thickness (Figures 4 and 5). The site was chosen for the purpose of developing interpretive methods for recognizing changes in bedrock. Orientation of bedrock units oblique to paleo-iceflow is important in our study of glacial dispersion models. A single long transect paralleling paleo-iceflow was surveyed. Site 3 (Red Dog) is an area of high mineral exploration interest (Figure 6). Little is known of the unconsolidated cover or the underlying bedrock geology. This area provides a test case for the techniques refined at the other two sites. A

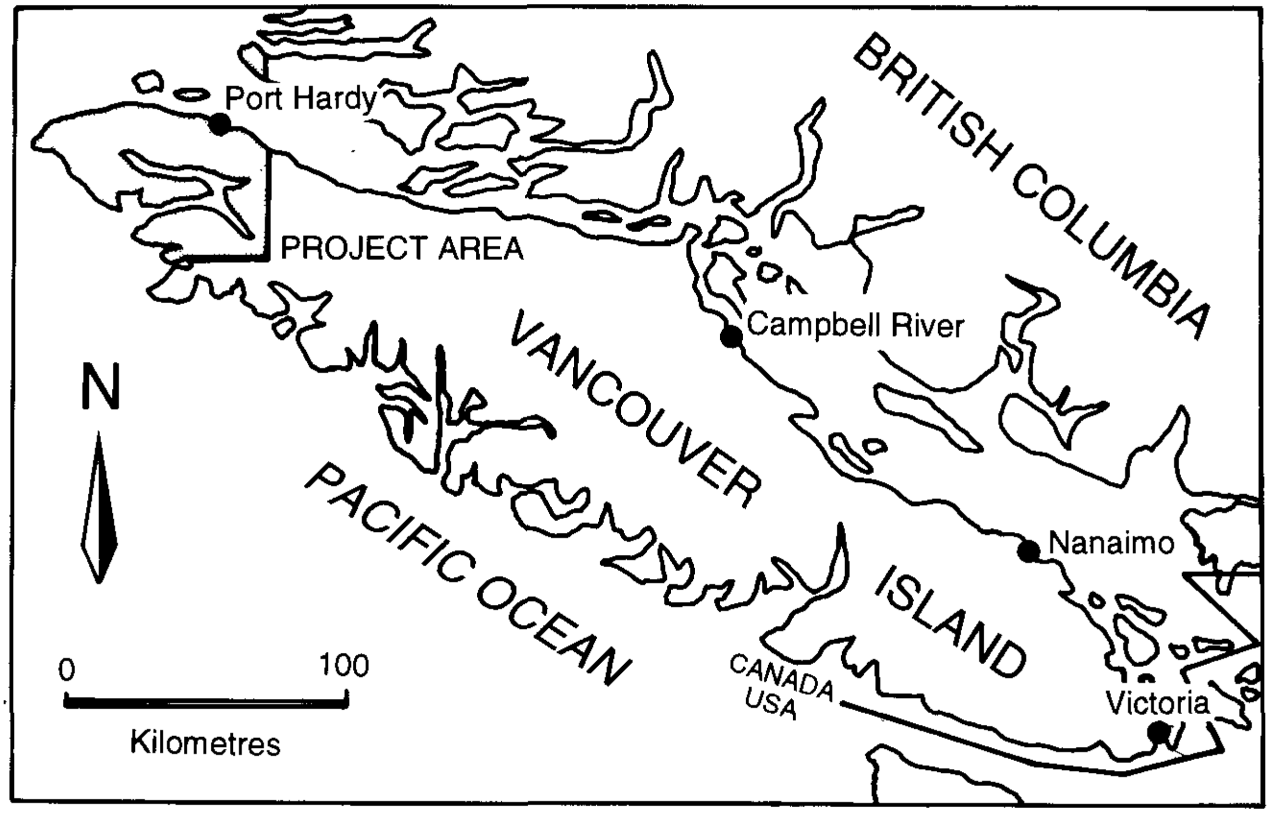

Figure 1. Integrated base metal exploration study area on northern Vancouver Island.

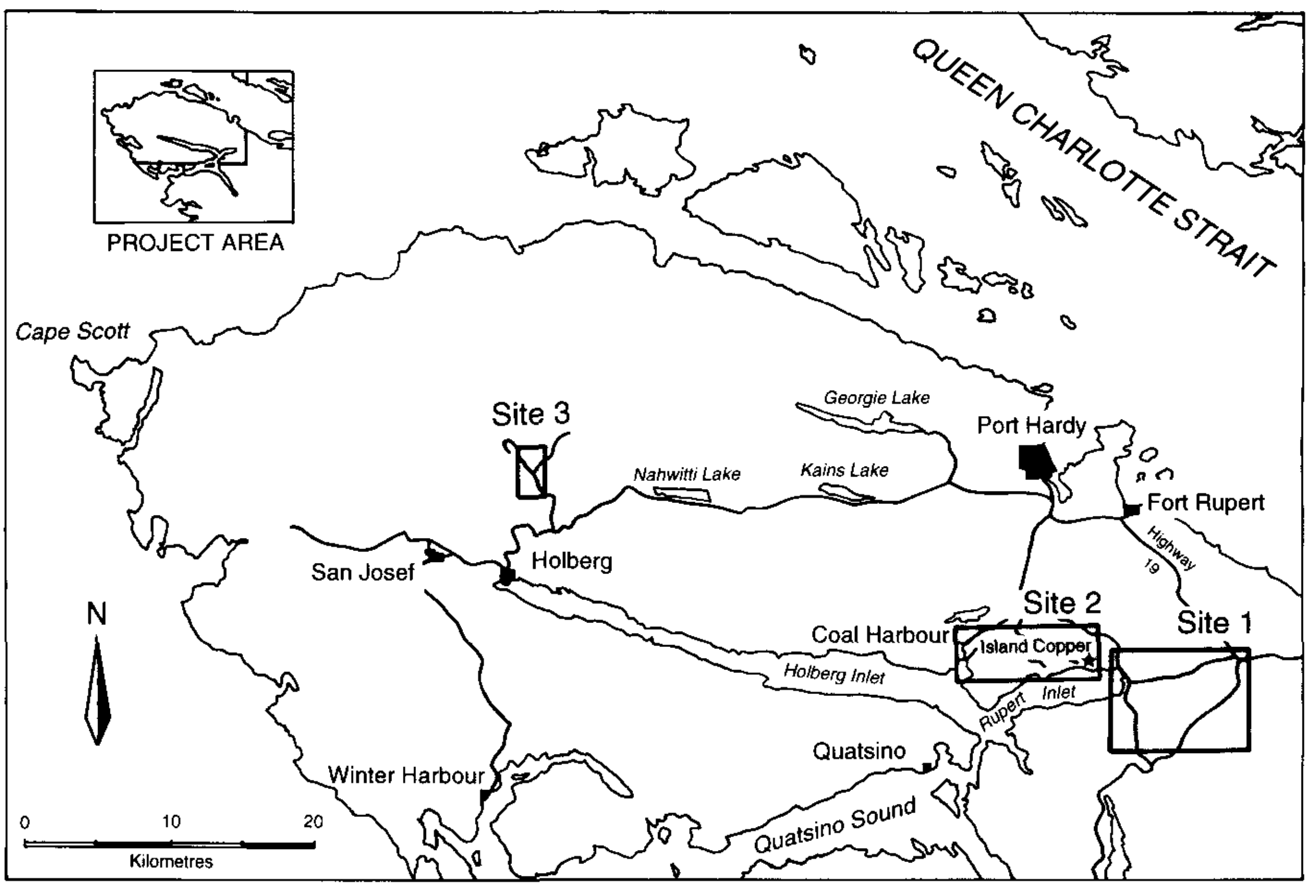

Figure 2 Cooperative BCGS-GSC drift exploration program study sites on northern Vancouver Island.

single transect was established in the area because of limited access. This example potentially allows us to evaluate methods of determining sediment thickness, composition and bedrock lithology.

SUBSURFACE PROGRAM

DRILLING RESEARCH

Drilling was carried out using a Mobile B-53 drill rig mounted on an International truck, owned and operated by Simon Fraser University (Photo 1). Mud rotary drilling was used to establish depth to bedrock and subsurface stratigraphy at Rupert Main (site 1, leg 1), whereas hollow-stem flight augering was used along View Point road (site 2) to obtain subsurface till samples for geochemical analysis (Table 1).

Mud rotary drilling was completed at a single location (NVI94-DH01) at site 1, leg 1 (Figure 3). The rig was positioned on a forestry spur road abutting a small lake to ensure a continuous water supply. A commercially available bentonite mud (Quick Gel™) in the ratio of about 10 kilograms per 400 litres of water was used as the drilling mud after propellor mixing to obtain the appropriate mud-water emulsion The drill hole

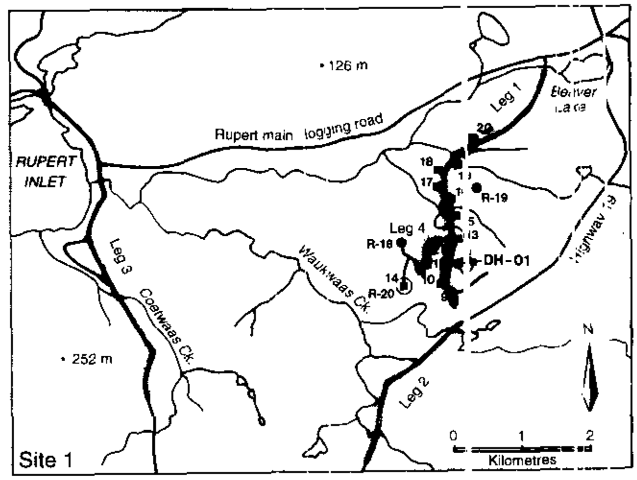

Figure 3. Detail of site 1 (Rupert Main) study area. Four transects numbered as legs 1 to 4; EM locations shown as numbered squares (*e.g.* ■ 5); BHP diamond-drill hole locations shown as numbered circles (*e.g.* • R-19); rotary and flight auger boreholes shown as numbered circles (*e.g.* • DH-01; • 4); spot elevations given as small dots (*e.g.* • 560 m). This key is consistent for figures 4, 5 and 6).

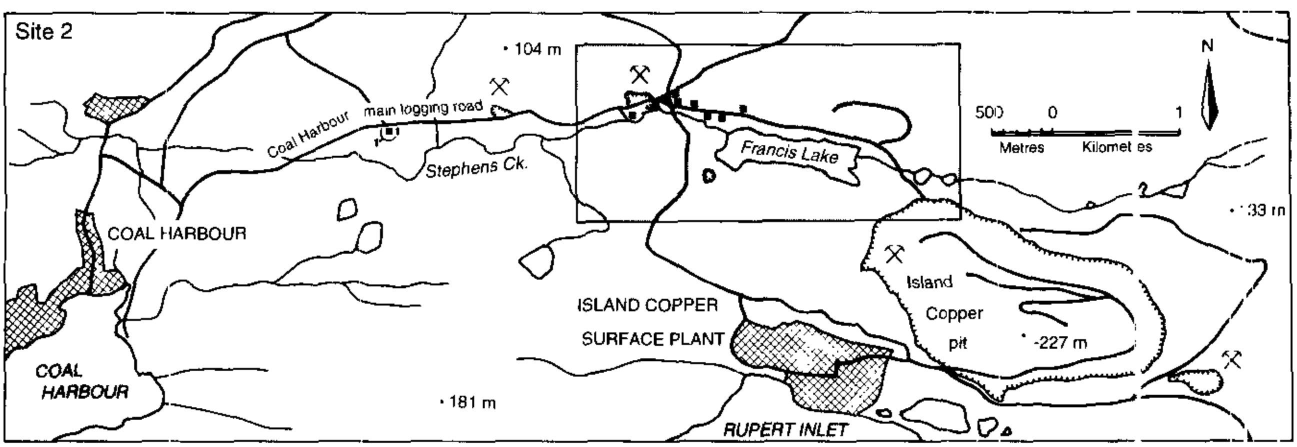

Figure 4. Location map of site 2 study area (View Point road). See Figure 2 for location. See Figure 3 for legend.

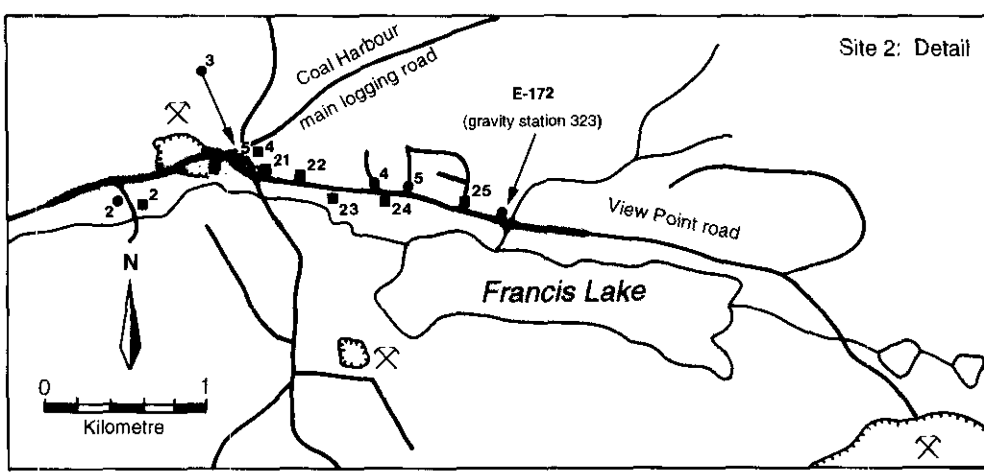

Figure 5. Detail of site 2 (View Point road). See Figure 4 for location. See Figure3 for legend.

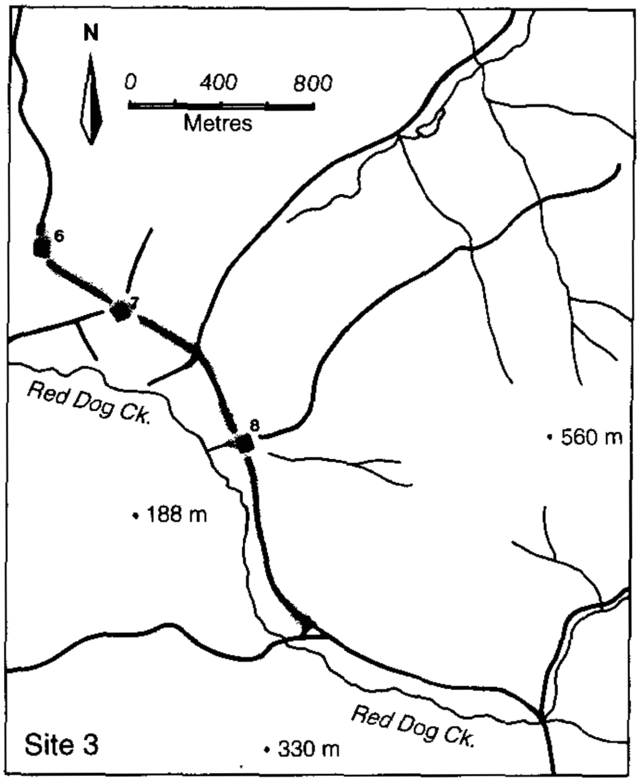

Figure 6. Detail of site 3 (Red Dog). See Figure 2 for location. See Figure 3 for legend.

was cased for 3 metres through the constructed road bed and partly into till after which a 10 centimetre tricone bit was advanced on a BW drill string. Core cuttings were constantly monitored and Shelby tube samples were occasionally obtained using a 70 kilogram drill mounted hammer. The drilling rate was routinely documented every 1.5 metres to provide indirect information on the various subsurface deposits.

An Acker 19-centimetre hollow-stem flight auger was used for drilling where rapid stratigraphic evaluation of the Quaternary surficial deposits and subsurface till geochemistry samples were needed. The flight auger apparatus proved ideal for quick geochemical sampling because the sediment attached to the auger corresponds to its original subsurface position. Contamination of the samples is minimized using this technique by removing the outer sediment surface when the auger is pulled. This method also avoids the use of drilling mud needed in conventional rotary drilling. Operational problems with the auger included large rock fragments in the upper road-fill which slowed initial drilling rates.

BOREHOLE LOGGING

Subsurface geophysical logging of boreholes was accomplished using a portable Mount Sopris 1000-C 300 logger (Photo 1). The 1000-C logger is equipped with metres of 2.5 millimetre steel-armoured cable with a tensile strength of 1000 pound (4.45 kilonewtons); such a strength is critical when a logging tool is trapped by lateral sediment squeezing which is common in Quaternary deposits The logging tool used for this project was a 41 millimetre (outer diameter) combination probe (HLP-2375/S) capable of recording the following properties: natural gamma radiation, spontaneous potential (SP) and resistance (R). All three characteristics were measured in uncased holes, whereas only natural gamma data were acquired for cased holes (whether steel or plastic).

Borehole geophysical logging was run in flight auger holes drilled at site 2 (Figure 4), and in the existing holes drilled by BHP Minerals Canada Limited as part of its exploration program at sites 1 and 2. Logging was extended into bedrock at BHP hole E-172 (Figure 5) to provide a background signature of the gamma signal in Bonanza volcanics which will provide a baseline for the interpretation of the Quaternary sediment signatures (*cf.* Asquith, 1982; Dewan, 1983; Serra, 1985).

SUBSURFACE RESULTS

Mud rotary hole NVI94-DH01 at site 1 (Figure 3) was drilled to a depth of 72 metres. Drilling terminated at this depth when the drill bit sheared from the rod as it penetrated compact sediments. Nonetheless, a variety of glacial sediments were described and sampled to this depth. A total of five auger holes were drilled along an east-west transect at site 2 (Figure 5). Average depth of drilling for the five holes was 3.7 metres and thirteen till samples were retrieved. Augering was restricted to locations with basal till to further the local till geochemistry survey (see below).

Exceptional results were obtained from the borehole geophysical logging. Figure 7 shows the gamma log for BHP hole R-19. This figure shows a stable signature for the lowermost 5 metres which represents compact, massive matrix-supported diamicton (lodgment till) overlying bedrock at 7.5 metres. At approximately 2.5 metres below ground surface the gamma signal weakens as it passes through loose, matrix-supported diamicton (ablation till) and weakens further from 1.5 to 1 metre when the upper soil horizon is measured. The strong signal for the topmost metre represents the artifical road fill consisting of crushed volcanic rock. This interpretation is verified from nearby surface exposures. BHP hole E-172 (corresponding to gravity station 323) displays a comparable record. From 14 to 6 metres below surface, the deposit most likely consists of stratified interbeds of sand and gravel (advance outwash). The upper 6 metres consists of upper soil horizons, lodgment till, ablation till and bedrock (Figure 8). The weaker road-bed signature at the top of the log reflects differences in road-fill at the two localities.

GRAVITY SURVEY

A total of 323 gravity measurements, at station intervals of 10 to 100 metres, were acquired at the three sites (Figure 2; Table 2). All stations were flagged to

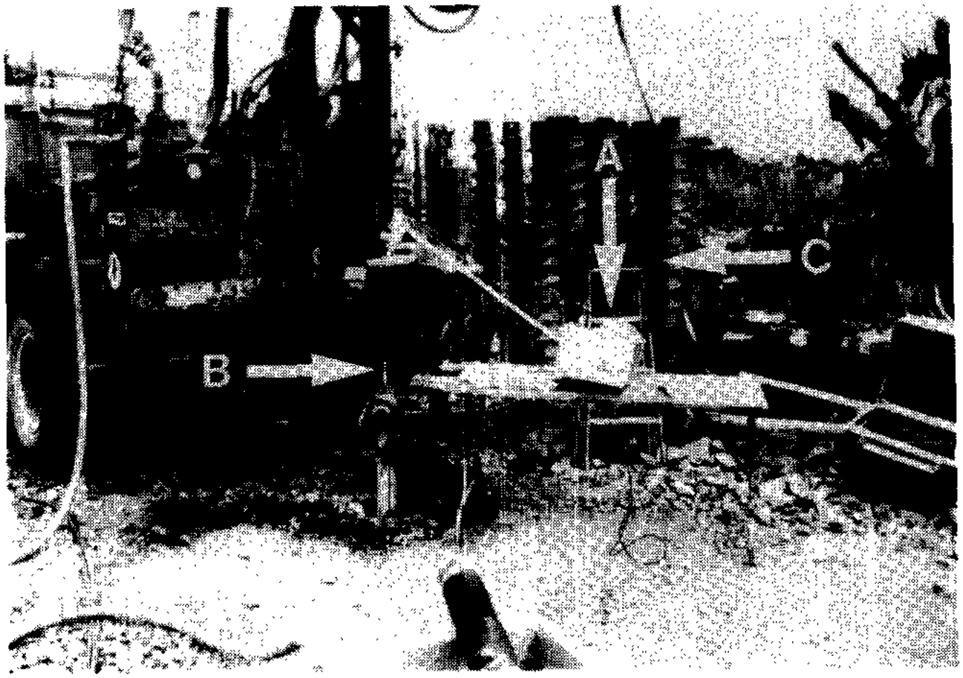

Photo 1. View of Mobile B-53 drill rig at site NVI94-DH01. Arrow A points to portable Mount Sopris 1000-C borehole logger. Arrow B points to 41-millimetre (outer diameter) combination probe at top of steel casing. Arrow C points to collection of 19-centimetre hollow-stem flight auger sections.

TABLE 1: DRILLING SUMMARY FOR NORTHERN VANCOUVER ISLAND

Drill hole number	Northing	Easting	Depth logged (m)	Casing	Gamma	SP	Resistivity
NVI94-FA01	5607450	603159	4.0	OPEN	-	-	-
NVI94-FA02	5607728	604753	2.7	OPEN	-	-	-
NVI94-FA03	5607852	605813	4.2	OPEN	-	-	-
NVI94-FA04	5607761	605426	2.7	OPEN	-	-	-
NVI94-FA05	5607743	605564	5.0	OPEN	-	-	-
NVI94-DH01[b]	5603791	617409	21.0	TOP 3 m	X	X	X
R-18[c]	5604240	616690	92.4	PVC	X	-	-
R-19	5605290	617850	7.5	OPEN	X	X	X
R-20	5603550	616500	38.8	OPEN	X	X	X
E-171[d]	5607939	605705	1.3	OPEN	X	-	-
E-172	5607689	605955	60.0	STEEL	X	-	-
E-175	5607875	605521	4.4	OPEN	X	-	-
E-176	5607763	607095	20.0	STEEL	X	-	-
E-178	5607674	606944	2.5	OPEN	X	-	-

a - flight auger holes by SFU
b - mud rotary drill hole by SFU
c - BHP diamond-drill hole
d - BHP diamond-drill hole

TABLE 2: GRAVITY AND MAGNETIC MEASUREMENTS FOR NORTHERN VANCOUVER ISLAND*

Site number	Leg number	Number of gravity stations	Number of magnetic stations	Station interval (m)	Profile length (km)
One	1	105	105	40	4.160
	2	31	-	100	3.000
	3	48	-	50	4.700
	4	15	15	50	0.700
Two	1	69	69	10-30	1.505
Three	1	55	-	40	2.160

* new gravity and magnetic measurements for 1994, see text for explanation.

using a LaCoste and Romber (model G) gravimeter. Daily surveying started and ended at a national gravity control station located in Port Hardy airport (station number 9275-67) near the study area. The maximum gravity closure error during the survey period was 0.074 milligal. Accuracy checks were performed by repeating gravity measurements at three stations. The mean gravity difference for repeat measurements was 0.15 milligal.

COORDINATE DATA

Two portable Trimble Pathfinder CA code global positioning data logging systems (GPS) were used to establish the latitude and longitude for 195 of the 323 gravity stations. Although this system is capable of providing station elevations, it is not sufficiently accurate for high-resolution gravity surveying. Station elevations were consequently determined using a Model D GDD electronic chain and level and altimetry. The coordinates of the remaining stations were determined by interpolation. To obtain the highest possible coordinate accuracy, the GPS receivers were operated in differential mode, that is, data were recorded simultaneously at the gravity station and at a temporary base station deployed in the area. All GPS data were then processed using the Pathfinder software package (P-Finder) supplied with the GPS system. Station latitudes and longitudes were typically located to within 5 metres.

Both electronic chain and level and a Paroscientific digital altimeter were used to provide greater control on station elevations. The chain and level apparatus provided very accurate relative height differences between stations along all traverses (vertical variation was typically less than a few centimetres). Absolute heights were subsequently calculated by running ties between the start of each traverse and the nearest geodetic bench mark.

GRAVITY RESULTS

Processing of the gravity data is in progress. Most of the measurements have been reduced to the International Gravity Standardization Net 1971 (Morelli, 1974) and theoretical gravity values calculated using the Geodetic Reference System 1967 gravity formula. Simple Bouguer anomalies have been calculated using standard density of 2670 kilograms per cubic metre, but terrain corrections have yet to be applied. Because the study sites are in low-relief terrain, it is anticipated that corrections will not be significant. Density determinations on both bedrock and drift samples will be undertaken in the near future and used to constrain quantitative gravity models.

Figure 9 shows the simple Bouguer anomaly along one traverse (leg 1) of the Rupert Main area (site 1). The anomaly reflects lateral density variations at all depths beneath the traverse including those related to topography on the bedrock surface. However, by ignoring the contribution of deep lateral density variations and assuming uniform composition of the unconsolidated sediments, this anomaly can be interpreted in terms of variations in overburden thickness. Briefly, for a north-south transect, the data suggest that drift thickness increases uniformly at distances between 0 and 1.8 kilometres, thins slightly over the distance 1.8 and 3.1 kilometres and then thickens significantly between 3.1 and 3.5 kilometres to the south. From this point onward, the overburden appears to thin appreciably.

MAGNETIC SURVEY

Total intensity field measurements were obtained at 189 stations along two traverses (legs 1 and 4) at Rupert Main (site 1) and the View Point road (site 2) using a portable Scintrex (model MP2) proton precession magnetometer (Table 2). The measurements

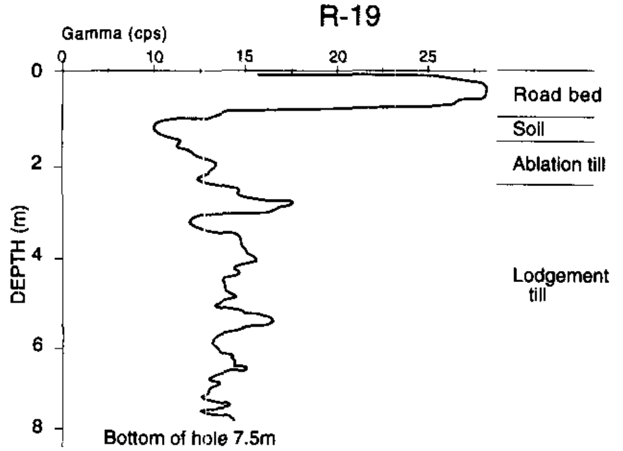

Figure 7. Gamma log through 7.5 metre BHP diamond-drill hole R-19 at site 1. See Figure 3 for location. See text for explanation

were made in the early fall during a period when predicted geomagnetic activity was very quiet (Figure 10). During magnetic storms, the magnetic field may vary by hundreds of nanoteslas over short time periods, thereby impeding magnetic surveying.

Representative samples of the bedrock and unconsolidated sediment were collected in the study sites. Samples will be analyzed to determine their magnetic susceptibility and the results will be used to constrain quantitative models of depth to basement.

MAGNETIC RESULTS

The raw data for leg 1 at site 1 (Rupert Main) show variations of several hundred nanoteslas (Figure 9). Assuming a simple two-layer model of non magnetic cover overlying magnetic basement, the data can be interpreted as suggesting: uniform drift thickness over the distance 0 to 1.7 kilometres, followed by an abrupt but short distance of sediment thinning (marked by gradients of more than 6 nanoteslas per metre), and a progressive thickening to the south with the exception of a 0.5 kilometre zone (2.8 to 3.3 kilometres) where overburden gradually thins. Magnetic measurements adjacent to the 1.7-kilometre magnetic anomaly spike, but off the traverse line suggest that the high values may be caused by a south-southeast-plunging body (fault or dike?) striking at around 340°. If this interpretation is correct and the shallowing of bedrock is in error, the interpretive models developed to determine overburden thickness are too simplistic in their starting assumptions and will be reevaluated.

ELECTROMAGNETIC SURVEY

The electromagnetic (EM) survey used a Geonics EM-47 (Protem) time-domain EM system in a central sounding mode; using a receiver at the centre of a square transmitter loop. The transmitter consisted of a

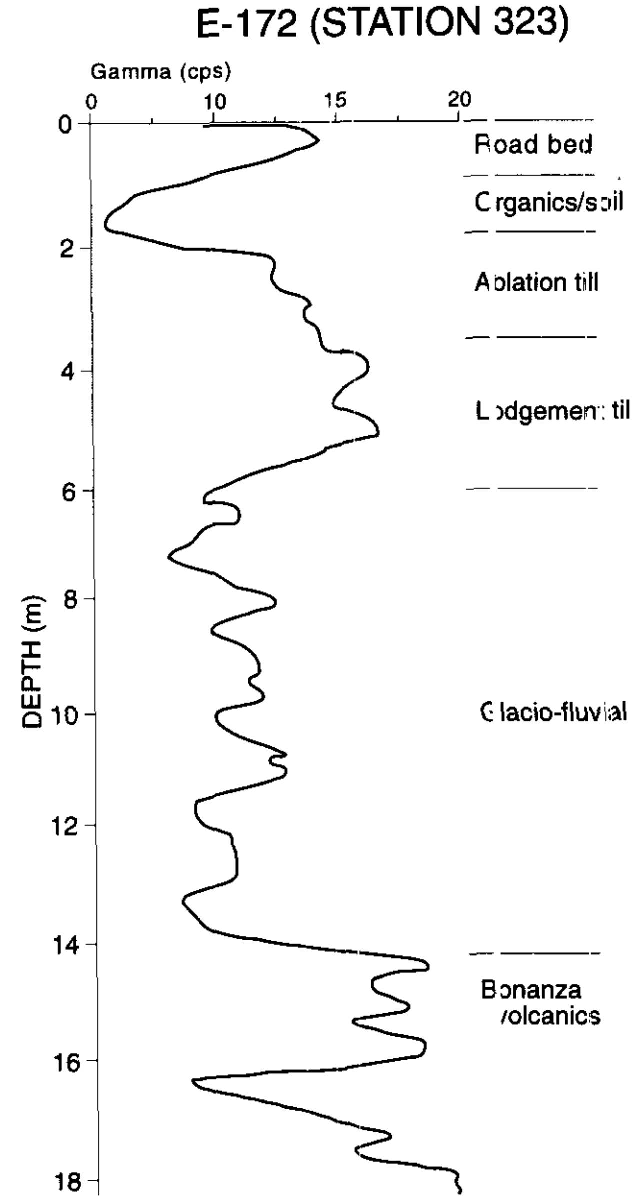

Figure 8. Gamma log showing upper 18 metres at BHP diamond-drill hole E-172 (gravity station 323 at site 2. See Figure 5 for location. See text for explanation.

arranged in the shape of a square loop with sides measuring 40 or 80 metres. The receiver coil was a multi-turn coil with a diameter of approximately 1 metre (coil area times the number of turns equal to 31.4 square metres). A reference cable was connected between the transmitter and receiver to control the timing of waveform transmission and voltage receipt

The transmitter current is an almost square wave with a sine-wave rise time and a linear ramp at the end of the square wave to turn off the current. The frequency of the square wave is defined as 1/T, where T is the period. The period consists of a positive square wave of duration T/4, followed by an off-time duration T/4. These are then reversed to give a total period of T.

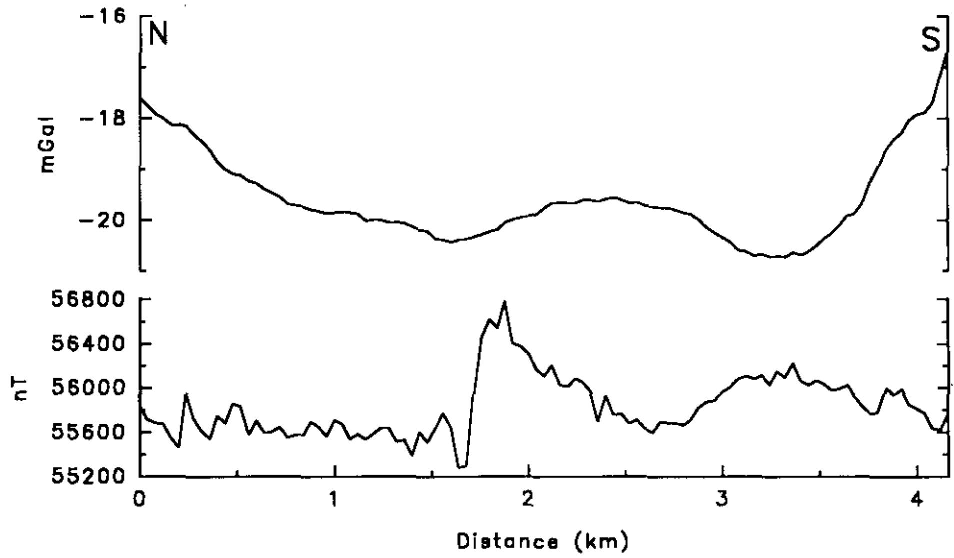

Figure 9. Rupert Main (site 1) leg 1 gravity and magnetic surveys. Upper diagram shows the Bouguer anomoly in milligal (mGal) and the lower diagram shows the magnetic anomaly in nanoteslas (nT). See text for details.

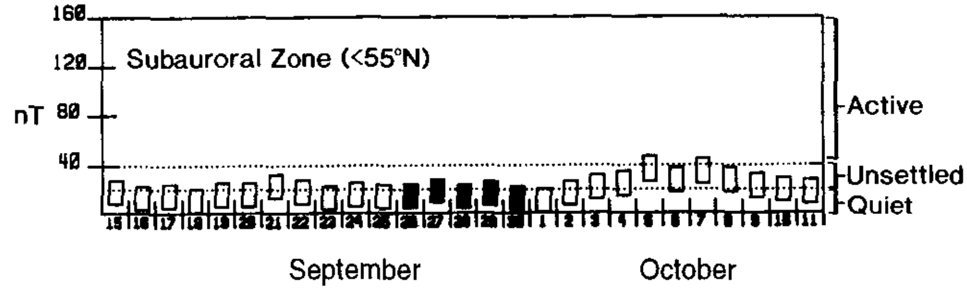

Figure 10. Predicted mean of geomagnetic activity levels for September 15 to October 11, 1994. As activity was forecast to be less than 20 nanoteslas (nT) for most of this period, it proved an ideal time for magnetic surveying.

The three frequencies associated with the EM-47 system are UH = ultra high frequency (285 Hz), VH = very high frequency (75 Hz) and H = high frequency (30 Hz).

The voltage measured by the EM-47 unit is measured in millivolts but is displayed as nanovolts per amp-metre squared (dipole moment) when plotted as a log-log function of time using TEMIXGL software from Interpex Limited, Golden, Colorado. The receiver voltage is measured in twenty time windows for each of the three frequencies. Times range from 6 microseconds to 7 milliseconds, with UH times from 6.85 microseconds to 701 microseconds, VH times from 48.3 microseconds to 2.825 milliseconds and H time from 100 microseconds to 704 milliseconds. The receiver voltage is sampled logarithmically in time. Each measurement is averaged over a time window and the time at the centre of the averaging window is defined to be the time for that window. The windows increase at longer times because the voltages are usually smaller.

The voltages are converted to apparent resistivity values using late-time normalized voltages (Fitterman and Stewart, 1986). The apparent resistivity is defined to be the ratio of the measured voltage to the voltage that would be measured over a half-space of constant resistivity. Once the apparent resistivity versus time curves are computed, the data can be interpreted in terms of multi-layered earth models using standard forward and inverse mathematical modelling programs. A number of assumptions are required to ensure the data can be meaningfully represented by a layered earth model. We used the TEMIXGL software package for modelling the data from the study area.

EM RESULTS

Edited log-log resistivity plots for two soundings obtained from site 1 (gravity stations 90 and 50) are shown in Figures 11 and 12. Solid lines reflect the apparent resistivity curves computed for the layered earth models shown in the figures. The squares, triangles and plus signs are the measured values of apparent resistivity. Note that sounding depths for overburden vary from approximately 23 metres at station 50 to 226 metres at station 90. Both models were obtained using the interactive graphics and inversion modes of the TEMIXGL software. Three iterations were required for the inversions to provide fitting errors of 7.7% and 13.4% for soundings 90 and 50, respectively.

The simple one-layer overburden interpretation for station 50 confirms airphoto interpretation and ground truthing observation for a shallow sediment cover in this area. Overburden at this location, 2 kilometres south along leg 1, consists of stratified sand, gravel and ablation till. In contrast, the data from station 90 suggest

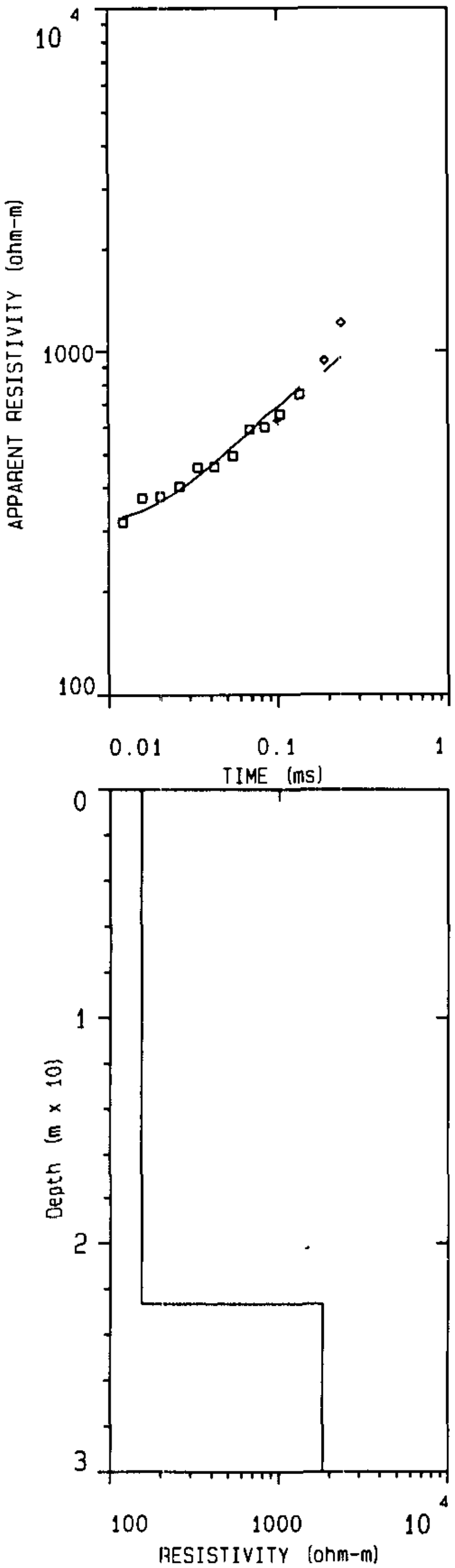

Figure 11. Electromagnetic survey at gravity station 50 (site 1). See Figure 3 for location. Top illustration shows apparent resistivity results in ohm-metres (ohm-m), whereas lower illustration shows stratigraphic interpretation. See text for details.

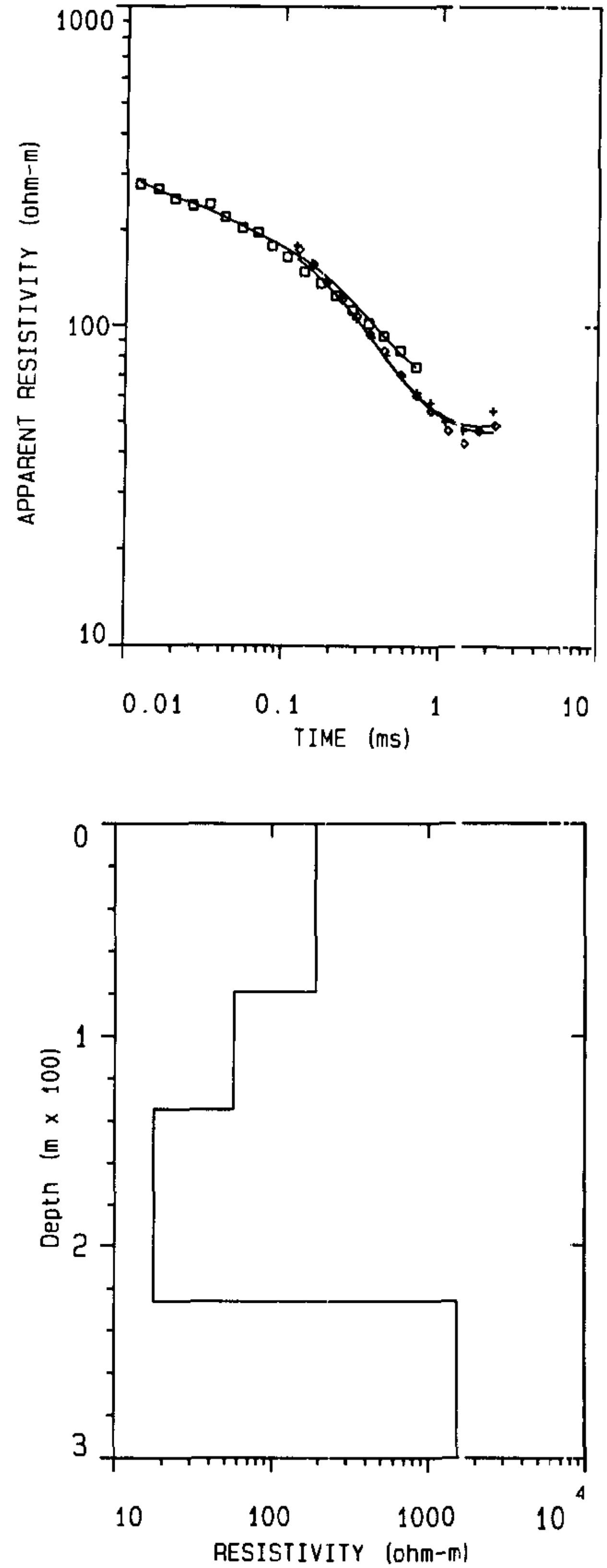

Figure 12. Electromagnetic survey at gravity station 90 (site 1). See Figure 3 for location. Top illustration shows apparent resistivity results in ohm-metres (ohm-m) whereas lower illustration shows stratigraphic interpretation. See text for details.

a sediment cover consisting of at least three distinct types of deposit. The resistivity of the upper 75 metres compares favourably with the sediment suite (drift) observed at station 50 and may also consist of sand/gravel and ablation till. At station 90, the resistivity interpretation indicates two other sediment complexes underlie the deglacial deposits. Bedrock was easily recognized by the EM-47 system at this significant depth (226 metres) only because of the large conductivity contrast of the conductive layer 80 metres thick (17 ohm-metre), directly overlying bedrock. Interpretation of the 150 metres of unconsolidated sediment over bedrock requires additional data analysis, including drill-hole logs and down-hole geophysical logs.

TILL GEOCHEMISTRY SURVEY

A detailed till geochemistry survey was undertaken at site 2 to complement the modelling and technique development component of the drift exploration program (Photo 2). The area was selected on the basis of detailed 1:2400-scale bedrock geology map data verified by diamond drilling. There is lithologically and mineralogically distinct bedrock striking around 180°; documented local and regional glacial paleo-iceflow perpendicular to the bedrock strike; good subsurface exposure of till along new road-cuts and at flight auger drilling stations; and proximity to a defined mineralized zone.

Bulk sediment samples (1 to 5 kilograms) of both oxidized and unoxidized basal till were collected along vertical profiles (Photo 2) and from five flight auger holes (Figures 4 and 5). Sample locations represent a fan-shaped transect which parallels documented paleo-ice-flow with sites up-ice and down-ice from mineralization. This study will be used to define glacial dispersal from the mineralized zone and the subsequent effect of soil formation on the geochemistry of the sediments. Representative splits of the +63-micron fraction samples will be submitted for aqua regia-extraction and inductively coupled plasma emission spectroscopy (ICP-ES) and instrumental neutron activation (INA) analysis.

BIOGEOCHEMISTRY SURVEY

Sampling undertaken will evaluate the effectiveness of biogeochemistry as an exploration tool in the northern Vancouver Island region. Studies in other regions have demonstrated that trees absorb and accumulate metals in their tissues, and by analyzing appropriate parts of trees it is possible to define areas of relative metal enrichment that may assist in locating zones of concealed mineralization.

A total of 248 samples were collected from 176 sites within a 10 by 50 kilometre east-west corridor on the north shore of Rupert Inlet, extending from Red Dog

Photo 2. View of till geochemistry survey station PTB94-105 near site 2. Eight till samples were taken down a 3.7 metre trenched face

(Figures 2 and 6), to east of the Island Copper mine (Figure 2). Detailed sampling was also conducted in the site 2 and site 3 areas to complement other geoscience studies. Western hemlock was chosen as the prime sample medium because it was present at all but a few of the desired sample sites. At each sample station, seven twigs were collected, that samped the last 10 years of growth. In reforested areas, only 3 to 5 years of growth could be evaluated. Tests are being conducted to determine if the composition of the younger growth is similar to that of the more common 10-year old sample. Samples of several different plant species were also collected to determine their relative sensitivities to the presence of a wide range of metals and pathfinder elements. The potential usefulness of each species for prospecting will be assessed from this information.

All samples were left to air dry (in paper bags) for one month before the foliage was separated from the twigs. Subsequently, all western hemlock twig samples were reduced to ash by ignition in a kiln at 470°C. A 0.5-gram portion was submitted for multi-element instrumental neutron activation analysis, and a 0.25-gram split was submitted for multi-element ICP-ES analysis. Preliminary results show a large area surrounding the Island Copper orebody that has unusually high concentrations of several metals, notably we found maxima of 240 ppb Au, 1241 ppm Mo and 4784 ppm Cu in ash.

CONCLUSIONS

The initial interpretations of the coincident drilling, gravity, magnetic and EM data are promising, although in some cases, inconsistent. Preliminary evaluation of the data sets indicates all methods have a high potential for providing useful information.

Although labour-intensive, we conclude that mud rotary drilling can be successfully used in complex surficial terrains consisting of dense till, coarse glaciofluvial sediment and cohesive marine deposits. In areas where borehole data are lacking, the effort expended by drilling is necessary to provide a means for examining the subsurface using borehole geophysics. Similarly, flight augering proved to be a quick and invaluable method for shallow subsurface testing and sampling.

Once drill holes are available, exceptional data return are provided by borehole geophysical methods. Although not discussed at length in this paper, gamma, SP and resistivity measurements all provide good detail about the composition of buried, unconsolidated sediments. Down-hole logging is quick, inexpensive and reliable and recommended for the evaluation of overburden cover where diamond drilling is undertaken.

Gravity, magnetometer and electromagnetic surveys all generated useful data. Both gravity and magnetometer measurements were easy to collect along the linear transects, whereas the EM surveying proved somewhat slower in the rough terrain. Results evaluated thus far are informative, although minor discrepancies exist. To date, our effort has primarily focused on the ability to establish overburden thickness. All three techniques were successful in dealing with sediment cover in excess of 200 metres in thickness. For example, for leg 1 at site 1, results for the three techniques are in rough agreement, indicating a general thickening of sediment from north to south. However, the magnetometer survey recognized a prominent anomaly mid-way along the section, not recognized by the gravity measurements. One noteworthy comparable interpretation is the identification of a substantial change in sediment character near drill hole NVI94-DH01. Both gravity and magnetometer data suggest there is a thick deposit of unconsolidated sediment in this area. The actual depth of bedrock was estimated to be 226 metres from the EM record, which also suggests a stratigraphic break at a depth of 72 metres. The latter break is confirmed by the mud rotary drilling at hole NVI94-DH01. The total depth to bedrock (226 m) is consistent with diamond drilling results within the general area.

In efforts to establish overburden thickness, the composition and character of the unconsolidated sediment cannot be overlooked. Similarly, the nature of the underlying bedrock plays an important rôle in the character of the data. Preliminary results indicate that the assumptions used thus far in the evaluation of our data are too simple. These data sets offer an opportunity to integrate methods and improve the interpretive models and algorithms. Further interpretation of the data from these sites will provide a better understanding of the limitations and capabilities of drilling, borehole geophysics, gravity, magnetometer and EM surveying for mapping drift thickness, composition and buried bedrock.

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