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Quaternary Geology and Till Geochemistry of the Huckleberry Mine Area

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INTRODUCTION

This paper summarizes Quaternary geology and till geochemistry studies conducted as part of a detailed case study on the Huckleberry Mine area. The study was initiated as a follow up to previous research conducted in the Nechako Plateau on the Late Wisconsinan glacial history of west-central British Columbia; specifically, studies that have confirmed the westward flow of ice from the interior of British Columbia towards the Pacific Ocean (Levson *et al*., 1998; Stumpf *et al*., 2000). Building on the deposit scale study of the Nak porphyry copper prospect (MINFILE No. 093M 010) (Levson *et al*., 1997), this paper also investigates the three-dimensional geometry of dispersal plumes in till. The purpose of this study is to:

- Build on the current ice-flow model of west-central British Columbia for the Late Wisconsinan through the identification and interpretation of small and intermediate scale erosional and streamlined forms, and dispersal trains and/or plumes in till; and
- Model dispersal of mineralization in till by investigating the two and three-dimensional geometry of dispersal plumes using selected clast lithologies and trace element geochemistry.

The results of this case study will be significant to the exploration community working in west-central British Columbia, as results will provide guidance on how to interpret till geochemical data and efficiently identify the bedrock source of anomalous till samples. As well, these results will suggest strategies on design and implementation of till geochemistry programs in areas with similar physical and geological characteristics and glacial histories. On a larger scale, this work is significant as it may be useful in developing and revising conceptual models of glacial dispersal and geochemical exploration.

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LOCATION AND PHYSICAL SETTING

Detailed stratigraphic, sedimentologic, and geochemical studies were conducted at Huckleberry Mine (MINFILE No. 093E 037), a producing porphyry copper-molybdenum open pit mine (north half of NTS 93E/11), while glacial history and ice flow studies extended into the surrounding area (NTS 93E/10-11, 93E/14-16) (Figure 1). This area was chosen for this 3-dimensional till study because a large number of overburden drill samples had been collected by Huckleberry Mines Ltd. (HBL) on the property and the type and distribution of mineralization in bedrock at Huckleberry Mine is well understood. In addition, the area has an extensive and thick mantle of Quaternary sediments and good access.

The Huckleberry Mine area falls within the transition zone between the Nechako Plateau, to the east, and the Coast Mountains, to the west (Figure 1). This area, the Tahtsa Ranges, is a belt of mountains 16-24 kilometres wide, with the highest peak being 2431 metres; the remaining peaks typically ranging from 2100 to 2250 metres. The Tahtsa Ranges are divided into east-west trending ranges by major valleys that are occupied by large lakes (*e.g. Tahtsa, Troitsa, and Whitesail Lakes). These lakes are prominent features of the Tahtsa Ranges, and they occur at a relatively high elevations (784 to 930 metres) therefore reducing the overall relief of the area (Holland, 1976). Valley bottoms and mountain flanks are forested and have thick sequences of Quaternary sediments with little bedrock exposure, while upper slopes and peaks extend into subalpine and alpine environments.*

Huckleberry Mine is located on the north side of Tahtsa Reach, approximately 130 kilometres due south of Smithers, or approximately 120 kilometres southwest of Houston, via Forest Service and private mine roads. The minesite is located in a poorly drained, boggy, arcuate shaped valley (averaging 1015 metres elevation), adjacent to the southern flank of Huckleberry Mountain (1526 metres) (Photo 1). Huckleberry Mine is a porphyry copper-molybdenum open pit mine, with minor recoverable amounts of gold and silver, and has a production rate of 21,000 tonnes/day ore. The mine has 185 direct employees and operates year round. Huckleberry Mine began production in 1997 with an estimated mine life of 11 years (Huckleberry, 2000).

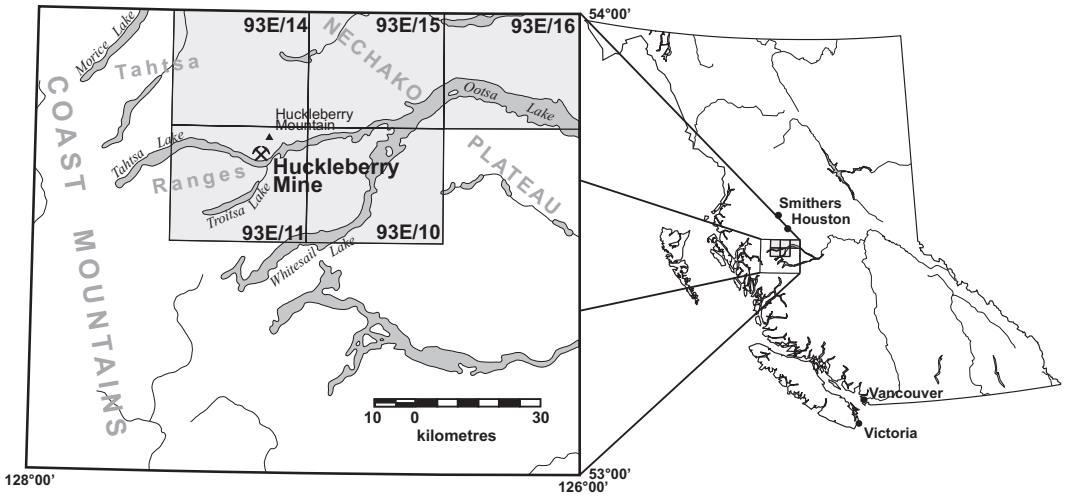

Figure 1. Study area location map.

Photo 1. Looking northeast towards Huckleberry Mine, Tahtsa Reach in foreground (photo courtesy of David Mate).

BEDROCK GEOLOGY

The study area lies just east of the Coast Crystalline Belt within the Intermontane Tectonic Belt (MacIntyre, 1985; Jackson and Illerbrun, 1995). It is underlain mainly by Early to Middle Jurassic Hazelton Group volcanic and sedimentary rocks, which are unconformably overlain by Bowser Lake sedimentary rocks of the Middle to Late Jurassic, and Early Cretaceous Skeena Group turbidites and basalt flows. These rocks are in turn unconformably overlain by Late Cretaceous Kasalka Group volcanics. Many small to medium, Late Cretaceous to Early Tertiary stocks have intruded these Jurassic and Cretaceous rocks (MacIntyre, 1985; Jackson and Illerbrun, 1995).

Underlying the Huckleberry Mine property are hornfelsed, fragmental, andesitic rocks of the Lower Jurassic Telkwa Formation, of the Hazelton Group (MacIntyre, 1985; Jackson and Illerbrun, 1995). These volcanic rocks have been intruded by two porphyritic hornblende-biotite-feldspar granodiorite stocks of the Late Cretaceous Bulkley Intrusions. Although there is copper and molybdenum mineralization within both stocks, nearly all ore mined is from the adjacent hornfelsed volcanic rocks (S. Blower, pers. comm., 2000). The Main Zone (15.6 million tonnes at 0.519% Cu) extends east from the most westerly stock into the adjacent hornfelsed volcanic rocks, while the East Zone (46.2 million tonnes at 0.488% Cu) is peripheral to the most easterly stock, within the adjacent hornfelsed volcanic rocks (Huckleberry, 2000). Mineralization is controlled both structurally and by the contact of the stocks themselves (Jackson and Illerbrun, 1995; S. Blower, pers. comm., 2000).

QUATERNARY GEOLOGY

The surficial geology of the study area was mapped by the British Columbia Ministry of Environment, Lands, and Parks (1976) at a scale of 1:50,000, while a more detailed 1:10,000 scale map of the Huckleberry Mine property was produced by New Canamin Resources (1993). In both cases, these maps are limited to the delineation and interpretation of surficial sediments only; identification and interpretation of landforms was not included. Other Quaternary geological studies have been conducted by Tipper (1994), Levson *et al.* (1998, 1999), Mate and Levson (1999), and Stumpf *et al*. (2000), but are limited to areas immediately adjacent to NTS 93E.

Surficial Geology

Detailed stratigraphic and sedimentologic studies were conducted at 12 exposures on the Huckleberry Mine property to better understand the glacial history of the area. Most Quaternary exposures studied were the result of mining and related activities (i.e. road cuts, borrow pits; see Photo 2), but also included natural gully exposures. Exposures ranged from a few to tens of metres high, with a maximum height of 27 metres, and a few to hundreds of metres long, with a maximum length of 250 metres.

The dominant surficial unit found in the study area is a massive diamict, 2.5 to 12 metres thick. It's character varies laterally and vertically, but it typically is a matrix-supported, sandy-silt, light brown to light gray, diamict. Locally the diamict is dark grey and clay-rich. It has moderately well developed vertical jointing and exhibits good sub-horizontal fissility and high density. Modal clast size is medium to large pebble, but ranges from granule up to large cobble. Clast shape is sub-angular to sub-rounded, with locally higher concentrations of angular to sub-angular clasts. Matrix percent is typically 60-80%, and striated clasts are common. Mineralized andesite and granodiorite clasts are common immediately adjacent to, and west of, the Main and East Zones; as are pyrite and chalcopyrite grains within the diamict matrix. Iron and manganese oxidation occurs mainly on joint planes, but near the surface (in the upper 1-2 metres) the entire diamict matrix is commonly oxidized. Where there is oxidation in the matrix, extreme weathering of clasts (in particular granitic lithologies) is common. Lower contacts are typically clear to diffuse, and sub-horizontal to weakly undulating. These characteristics are consistent with those of a subglacially derived diamict (Dreimanis, 1989), and this unit is therefore interpreted as a basal till (Photo 3).

In most sections, this basal till overlies polished, grooved, and striated bedrock, but locally can overlie clast-supported, matrix-filled, rounded, small to large pebble gravels, commonly with cross-bedded, fine to coarse-grained sand lenses, ranging from a few centimetres to a few metres wide, and a few centimetres to tens of centimetres high. These gravel units are up to 3 metres thick, and have sharp, trough-shaped lower contacts. They are interpreted as being glaciofluvial in origin. Basal till also locally overlies laminated silts and clays, and thinly bedded, fine to medium-grained sands, that contain numerous, small to medium pebble dropstones and deformed sedimentary structures. These silts and clays are commonly interbedded with massive, matrix supported, sandy diamict lenses, 2 to 3 metres in length, and up to 1 metre high. Lenses have sharp, small scale (5 to 30 centimetres long, 0.5 to 1 centimetre high) undulatory to trough shaped lower contacts. Silt and clay units are up to 3 metres thick, and have sharp, planar to sub-horizontal lower contacts. They are interpreted as glaciolacustrine (possibly subglacial) sediments, with interbedded subaqueous debris flow deposits. They are

Photo 2. West Borrow Pit where till was excavated for use in tailings dam construction. This Pit was one of the 12 exposures studied on the Huckleberry Mine property. Note the trucks in foreground for scale.

Photo 3. Basal till, the dominant surficial unit found in the study area, overlying mineralized volcanics within the Main Zone. The till is overconsolidated and stands vertical in excavation.

only observed in exposures in the vicinity of the East Zone.

Glacial units are typically capped on steep valley slopes by angular to subangular, medium pebble to large cobble, colluvial deposits up to 1metre thick. In valley bottom settings they commonly grade upwards into organic soils. The depth of Holocene soil development on well drained soils varies from a few tens of centimetres to about 1 metre.

Quaternary geological studies within NTS 93E, have not yet produced any sub-till radiocarbon dates. However, 100 kilometres east of the Huckleberry Mine area, on Cheslaslie Arm, organic rich sediments that underlie till have produced dates that range from approximately 27 000 to >45 000 years B.P. (Levson and Giles, 1997; Levson *et al*., 1998). As well, nonglacial sediments under till that have yielded finite radiocarbon dates occur in a number of other localities farther east in the Nechako Plateau (Plouffe and Jetté, 1997; Plouffe and Levson, 2001) and to the north in the Babine Lake area, approximately 200 kilometres north of the Huckleberry Mine area at the Bell Mine (Harington *et al.*, 1974; Levson, 2001a). The Quaternary sediments of the Huckleberry Mine area are believed to be correlative with those found in areas adjacent to NTS 93E, which overlie these dated lacustrine and organic rich deposits. The Quaternary sediments of the Huckleberry Mine area are therefore interpreted as being Late Wisconsinan to Holocene in age.

Ice Flow Indicators

Ice flow data were observed and recorded at over 130 ice flow stations. Most striated outcrops were observed in valley bottom settings along roads and shorelines along Tahtsa Reach, Tahtsa Lake and Ootsa Lake. Data were also collected at elevations over 1500 metres at six mountain peaks. Various small scale (grooves, striae, rat tails) and intermediate scale (roches moutonnées, crag and tails, flutes, and drumlins) streamlined forms, were studied to better understand the ice flow history of the Huckleberry Mine area. The distribution of selected clast lithologies in till were also investigated for this reason.

Data collected at each ice flow station included: general site description (topographic position, aspect, slope); orientation and dimensions of form; and relative degree of preservation of forms. Particular attention was given to: stoss (up-ice) and lee (down-ice) face relationships, the media the form was created and preserved in, and cross-cutting and/or superimposition relationships with other forms. These observations are important not only when interpreting ice flow direction, but in determining the timing and magnitude of multiple ice flow events. As most of these sites are in human-disturbed areas, correct identification of linear forms was important (i.e. natural or human-made). To supplement this data, air photo interpretation was ongoing while in the field.

In addition to this, fabric measurements and pebble counts were taken in undisturbed till, at Huckleberry Mine. For fabric measurements, clast shape, a-axis trend and plunge, and the presence and orientation of striae on clasts relative to a-axis orientation, were recorded. In the case of pebble counts, clasts were first categorized based on lithology and then described in terms of roundness and presence of mineralization. Stratigraphic and sedimentologic descriptions were completed at each of the fabric and pebble count sites, with particular attention given to site location relative to the Main and East Zones.

TILL GEOCHEMISTRY

To date, no till geochemistry programs have been conducted in the Huckleberry Mine area, however various other geochemical programs were completed by exploration companies. The Len Claims, now the Huckleberry Mine property, were staked in 1962 by Kennco Explorations (Western) Ltd., as a result of follow up work on anomalous stream sediment samples collected in 1960 (Jackson and Illerbrun, 1995). Shortly after staking, Hornbrook (1970) conducted a biogeochemical and geochemical prospecting program on these claims, as part of a comparative study on the effectiveness of biogeochemical surveys for detecting buried mineral deposits. Since then, three soil geochemistry surveys have been conducted on the Huckleberry Mine property as a part of advanced exploration programs (Stevenson, 1970; Bradish *et al.*, 1989; Myers and Roney, 1990). On a regional scale, the British Columbia Ministry of Energy and Mines and the Geological Survey of Canada conducted a Regional Geochemical Survey (RGS) of NTS 93E (RGS, BC RGS 16/GSC Open File 1360, 1987).

The objectives of this detailed till geochemistry program are to identify anomalous copper values in till, and to determine the relationship between these values at the surface and in profile, and their bedrock source(s). As well, by investigating changes in copper concentration in till with increasing vertical and horizontal distance from known mineralization, direction of ice flow can be determined, and geochemical values in till for a given distance from known mineralization can be modelled. The likelihood of meeting these objectives is enhanced because the trend of ice flow is known to be valley-parallel, the type and distribution of mineralization in bedrock is well understood, and the depth of till in many places is known or can be inferred.

Sample Media

Basal till, a first derivative of bedrock (Shilts, 1993), is transported in a relatively linear fashion parallel to ice flow direction, down ice of it's bedrock source. Mineral anomalies in basal till tend to be relatively large, and the contrast between anomalous and background geochemical values can be clear. Geochemical patterns found in basal till produce a regional signature, whereas residual soils and colluvium reflect more local geochemical variations (Levson, 2001b). Likewise, second or third derivative sediments, such as glaciofluvial or glaciolacustrine sediments, typically have much more complex transport histories than basal till. These characteristics of basal till make it an effective tool for tracing anomalous geochemical values back to their bedrock sources, and is one reason why basal till (previously described in the Surficial Geology section of this paper) was chosen as the sample media for this study.

While conducting a till geochemistry program, the proper identification of sample media is imperative, not only to ensure consistency between sample sites but also to ensure that the origin and mode of transportation and deposition of the sampled sediments is understood when interpreting geochemical results (Levson, 2001b). At each sample site, sedimentological data such as: type of sediment and thickness; primary and secondary structures; density; matrix percent, texture, and colour; clast mode, shape, and presence of striae, were collected. These data were collected in order to ensure the proper identification of basal till from other sediment types such as colluvium, debris flows, and glaciolacustrine diamicts. As well, at each sample site, notes were made on: type of exposure sampled; terrain map unit; sample site geomorphology (*e.g.* topographic position, aspect, slope, drainage); stratigraphy; and the type and thickness of soil horizons present. These data were collected to assess which surficial processes, if any, could have physically or geochemically altered the sediments sampled. Again, this information can be critical when interpreting geochemical data.

At each sample site, clasts found in till were examined in detail. Data such as, clast lithology, shape (i.e. rounded, sub-rounded, sub-angular, or angular), size, presence of striae, and presence of mineralization, were recorded. From these data, inferences on clast provenance can be made, as well as interpretation of ice flow direction.

Sample Types

During the course of the 2000 field season 452 samples of surficial sediments were collected on the Huckleberry Mine property: 205 of basal till from Becker Hammer boreholes; 71 from till, soil, and peat profiles; and 176 routine surface samples of basal till. Sample sites were selected to optimize spatial coverage of the study area, taking into account ice flow direction and location of ore bodies. Limitations on sample site selection were due mainly to the absence of appropriate sample media, but were also a result of human disturbance (*e.g. tailings pond location, re-working of surficial sediments by heavy machinery, road beds, etc.). Becker Hammer drill site locations were selected by HBL with no input as a result of this program.*

From 1998-2000, HBL carried out a Becker Hammer drill program as part of on-site geotechnical investigations for appropriate tailings dam construction material. Basal till samples were collected at depth which enabled HBL to evaluate the quality and quantity of basal till available. Quaternary sediments were sampled at depths up to 29 metres with a Becker Hammer drill rig which hydraulically pounds a hollow drill stem into the substrate. Cohesive sediments, like basal till, come up the drill stem in consolidated balls 10-15 centimetres in diameter; samples were taken and logged every 1.3 metres (4 feet). Sample splits of these consolidated balls were taken from every sample interval where till was recovered in sufficient quantity and quality. Much emphasis was put on sample preparation, which included describing the characteristics of each sample, scraping the outside surfaces of the samples to remove other sediments, and examining sample splits for possible reconstitution as the original

sample was brought up the drill stem. As part of this study, 19 of the boreholes were sampled throughout their length, and 28 were sampled at or near the surface (Figure 2, lower half).

To supplement these borehole samples, profile sampling was conducted in basal tills, peats, and soils, at 13 sites on the Huckleberry Mine property (Figure 2, lower half). At each of these sites, detailed stratigraphic descriptions were completed followed by sampling of each stratigraphic unit identified. These profiles ranged in depth from 1 to 9.5 metres. Borehole and profile samples will be used to investigate horizontal and vertical geochemical dispersal in basal till.

Routine surface samples also were taken mainly along roadcuts on the Huckleberry Mine property, but included other artificial sites (trenches, soil and borrow pits) and natural sites (wave-cut banks on lake shorelines and gullies). Average sample depth was about 200 centimetres below surface, but ranged from 50 to 850 cm. To test dispersal direction, and change in copper values in till with distance from known mineralization, valley-parallel, east/west sample transects were run along roadcuts north and south of the Main and East Zone pits. Sample spacing varied from approximately 100 metres on the northern transect to approximately 500 metres on the southern transect. In addition, samples were taken (sample spacing of 250 to 500 m) up to 4 kilometres west of the Main Zone, and up to 2 kilometres east of the East Zone, to again test for dispersal direction and changes in copper values in till with distance from these known sources of mineralization (Figure 2, upper half).

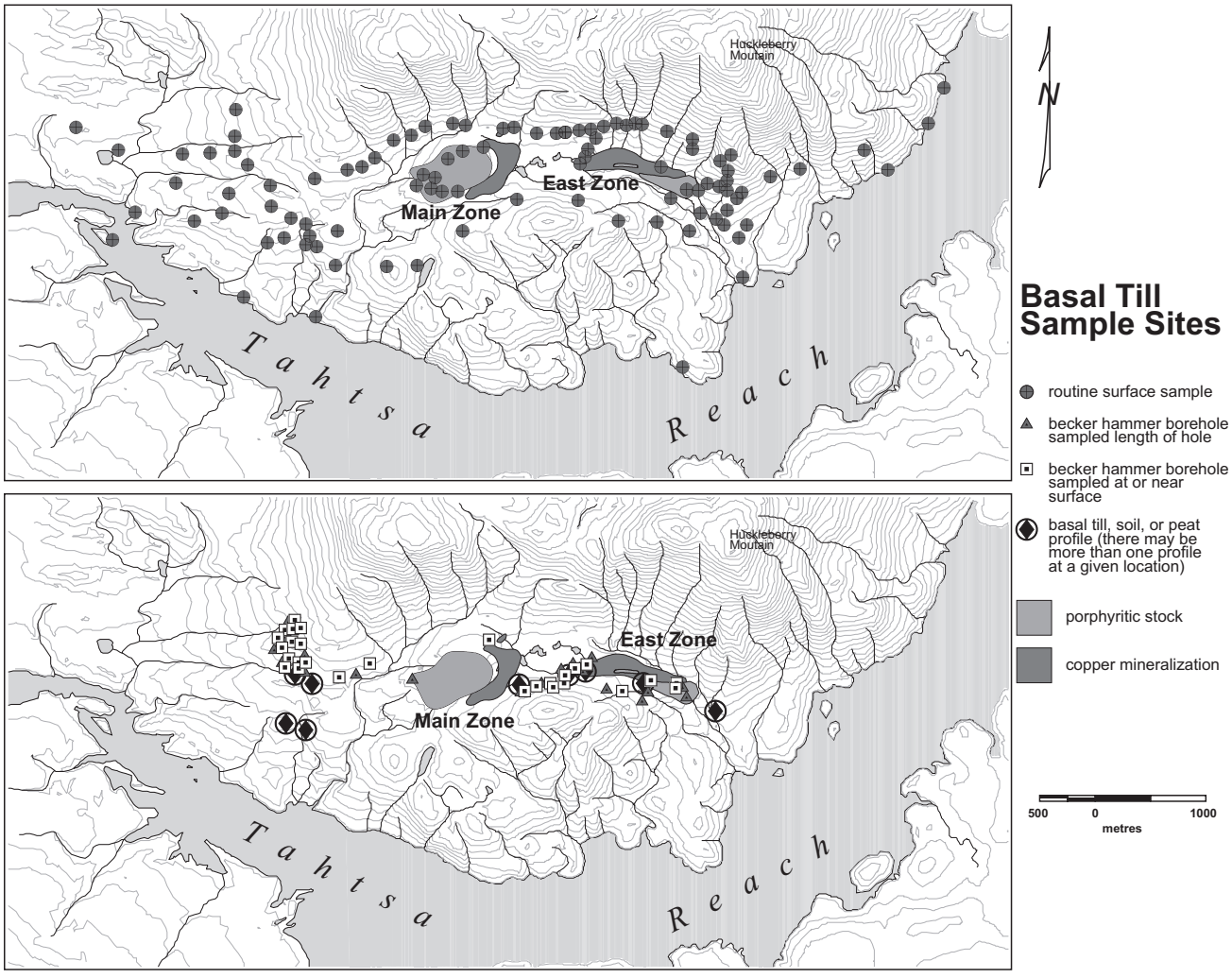

Figure 2. Upper: routine surface sample locations; Lower: Becker Hammer borehole sample, and basal till, peat, and soil profile locations.

Laboratory Methods

Samples collected for this study, ranging from 2 to 5 kilograms, were air dried, split and sieved to –230 mesh (<62.5 mm). This fraction was analyzed for a total of 52 elements by instrumental neutron activation (INA) at Activation Laboratories Ltd. in Ancaster, Ontario and by inductively coupled plasma mass spectrometry (ICP-MS) at Acme Analytical Laboratories Ltd. in Vancouver, British Columbia. Half of each sample split was archived for grain size or other follow-up analyses.

In each block of 20 samples submitted for analyses, 17 are routine field samples. The remaining 3 samples are quality control measures, utilized in both the sample collection and sample analysis components of the study, to differentiate true geochemical trends from those that reflect random and systematic sampling or analytical errors. Quality control measures include the use of field duplicates, analytical duplicates, and control standards.

ICE FLOW HISTORY OF THE HUCKLEBERRY MINE AREA

The Huckleberry Mine area has a complex glacial history. Preliminary results suggest there are two dominant ice flow directions in the region, 236º-265º and 40º-91º (Figure 3). The results also suggest that ice flow direction, and the preservation of ice flow indicators, have been effected at least in part by topography and/or elevation. In addition, air photo interpretation alone locally yields different results than field studies. For example in the region east of the Huckleberry Mine, the orientation of intermediate to large scale erosional and streamlined landforms suggests a dominant ice flow direction of east to northeast during the last glacial maximum. However, field investigations of these landforms and small scale features suggest a more complex ice flow history with an earlier westerly flow event followed by the east to northeast event.

At relatively high elevation sites (>1500 metres), west to southwest flow is clearly indicated in well preserved landforms such as roche moutonnée, striae, and rat tails, and is the only direction preserved here (Photo 4). At these sites there is no evidence of topographic control as these features are observed with orientations that cross mountain tops and do not conform to the trend of the adjacent valleys. At lower elevations, in valley bottoms and along lake shores in particular, the preserved record of ice flow direction is much more complicated. Along the shores of Tahtsa Reach and Tahtsa and Ootsa lakes for example, ice flow was topographically controlled and appears to have flowed parallel to the valleys, regardless of the regional ice flow direction. At these lower elevation sites it is common to find west to southwest and east to northeast ice flow indicators on opposite sides of the same outcrop (Photo 5). It is also common to find evidence of one flow direction superimposed on a landform which indicates flow in the opposite direction.

Based on the relative degree of landform preservation, and the magnitude of these opposing ice flow events inferred from cross-cutting and/or superimposition relationships, the west to southwest event appears to be earlier and of a larger magnitude than the east to northeast

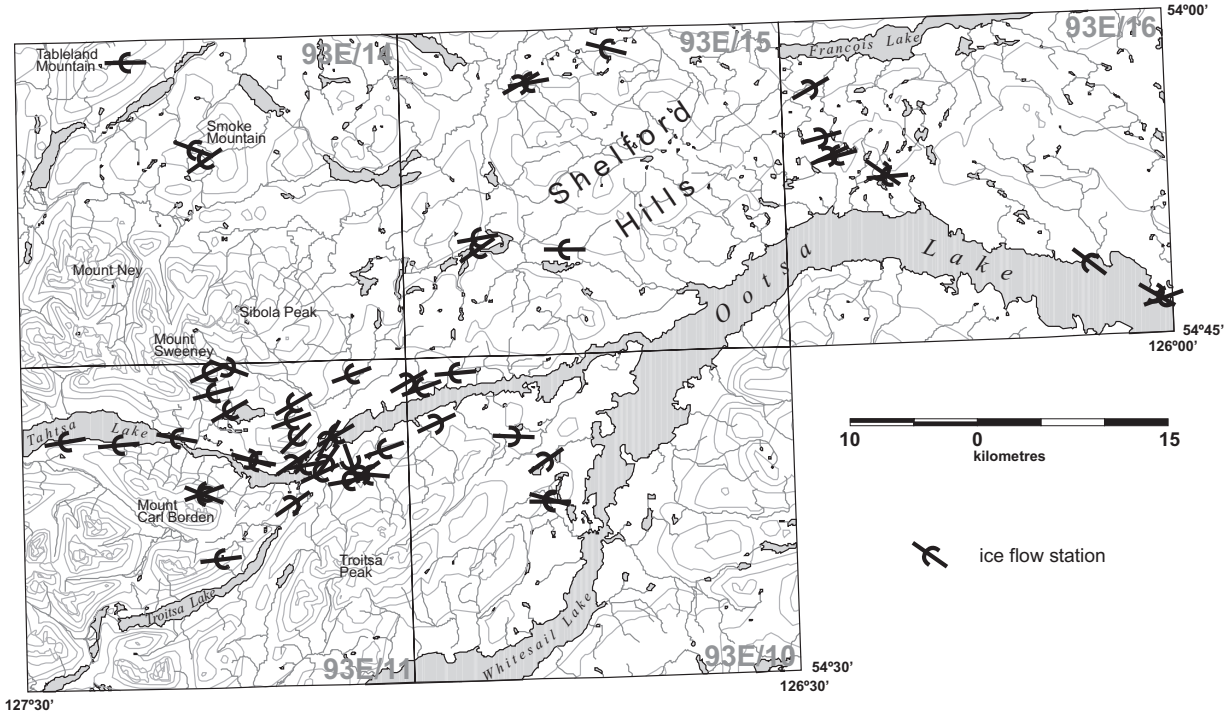

Figure 3. Ice flow stations with inferred ice flow direction. Ice flow data are generalized to improve clarity.

Photo 4. Roche moutonnée on Smoke Mountain (1707 metres asl) showing evidence of southwest ice flow (in photo, ice flow direction is from left to right).

event. In other words, in the Huckleberry Mine area west to southwest flow dominated during the Fraser Glaciation maximum and was followed in some low elevation areas by a weaker, possibly shorter lived, east to northeast ice flow event. These results are in general agreement with those discussed by Levson *et al*. (1998, 1999), and Stumpf *et al.* (2000), and indicate the presence of an ice dome in central British Columbia during the Fraser Glaciation maximum. With the development of this ice dome, ice that once flowed east from the Coast Mountains, controlled by the Tahtsa and Ootsa Lake valleys, now flowed west to southwest back through these valleys and over neighbouring mountain peaks producing the observed west to southwest ice flow indicators. Towards the end of the Late Wisconsinan this divide locally shifted west, back towards the Coast Mountains, and as the ice sheet began to thin, ice flow resumed natural drainage patterns producing the east to northeast ice flow indicators observed in air photos and in the field. Evidence of early ice flow eastward out of the Coast Mountains was probably obliterated in many areas by the westward flow event; of the 136 ice flow stations visited, only a few provided good evidence of an earlier eastward ice flow event although in many case it is difficult to differentiate early and late easterly flow indicators.

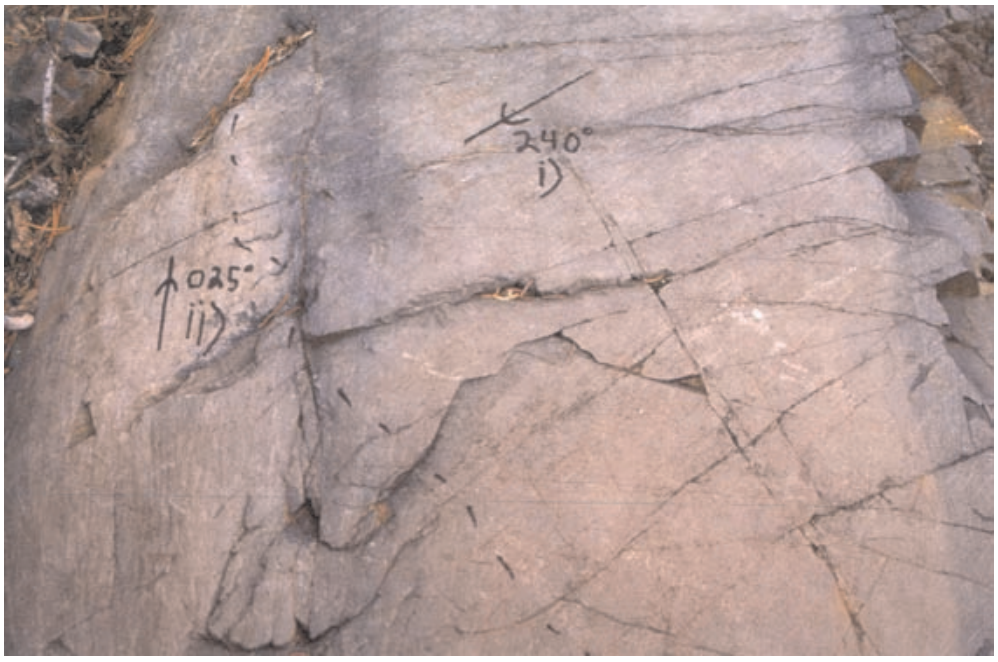

Photo 5. Typical striated outcrop observed at lower elevation sites (Tahtsa Reach) , with evidence of two ice flow events (i) earlier southwest ice flow; (ii) later northeast ice flow.

GEOCHEMICAL CHARACTERISTICS OF THE HUCKLEBERRY MINE AREA TILLS - PRELIMINARY RESULTS

At the time of writing, geochemical analyses had been completed on only 18 of the 205 Becker Hammer borehole samples collected. These 18 samples closely follow an east-west transect through the Main and East Zones (Figure 4), but were taken at various depths below surface (Table 1); two samples were taken from boreholes OB98-11, OB99-26, and OB99-36 at different depths. Figure 5 shows how copper concentrations of these 18 samples vary relative to depth below surface and distance from known mineralization. As well, at the time of writing, geochemical analyses had been completed for 48 of the 176 routine surface basal till samples collected. Copper concentrations at these sample sites are plotted in Figure 6 as a graduated symbol map and they are shown relative to the two primary zones of known copper mineralization in bedrock. Routine surface sample sites north and south of the Main and East Zones, and east of the East Zone, were collected in the early stages of this study to determine the local signature of the orebodies and to test for westerly dispersal of mineralization. The sites west of the Main Zone were sampled in the later stages of this study to investigate the probable source of a high copper value encountered in the till in that area in the early part of the study.

The median copper concentration of the 66 samples analyzed to date is 181 ppm, with a minimum value of 43 ppm and a maximum of 8924 ppm. Only 13 had copper concentrations of less than 100 ppm. In general, copper concentrations below 100 ppm are found at distances greater than about 1 kilometre from known mineralization or they occur at sites off the trend of the valley that hosts the Huckleberry porphyry system (Figure 6). The highest copper concentration in till in the area (8924 ppm) occurs at the west end of the Main Zone where the sample was taken 30 centimetres above mineralized volcanics. The bedrock at this site had a 0.5 to 1.0 centimetre thick amorphous precipitate of an unknown chemical composition suggesting that the anomalously high copper content in the till at this site is a result of groundwater transport of copper in solution. Similarly, high copper in till (446 ppm) at a site directly downslope (southeast) of the East Zone may be the result of hydromorphic dispersion. Strong iron staining of surface till and pronounced groundwater seepage observed this site provides good evidence for the movement of metals in solution in that area. Aside from this site, most other surface tills in the vicinity of the East Zone have copper contents less than the area median and values drop quickly to levels as low as 63 ppm directly southeast of the East Zone. In contrast, copper concentrations at most sites west of both the East and Main zones exceed the median and several exceed the 70th percentile (245 ppm) for surface tills in the area (Fig-

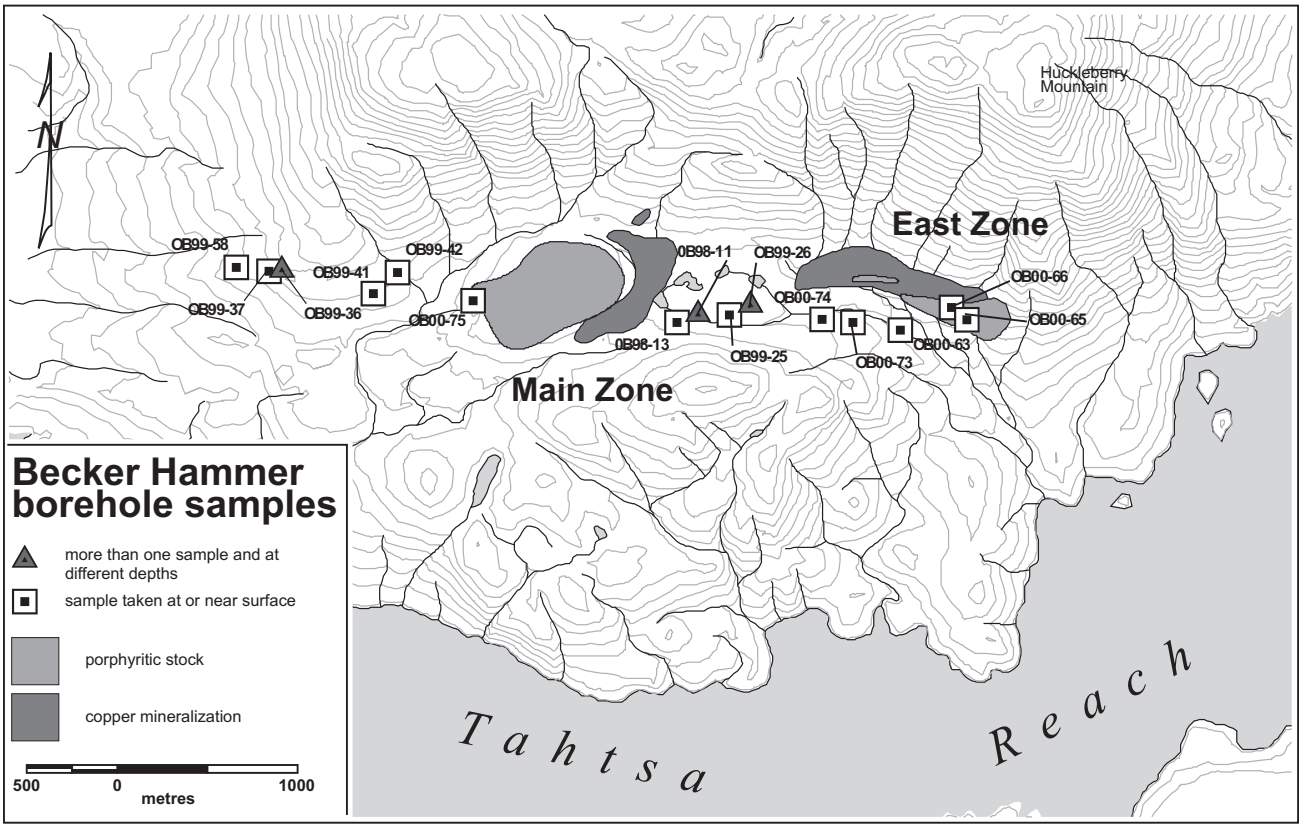

Figure 4. Location of the 18 Becker Hammer borehole samples analysed to date.

TABLE 1
SUMMARY TABLE OF BECKER HAMMER BOREHOLE SAMPLES ANALYZED TO DATE

Becker Hammer Borehole ID	Depth to Bedrock (m)	Sample Interval Below Surface (m)	Copper (ppm)
0B98-11	14.4	8.0 - 9.3	144
0B98-11	14.4	13.3 - 14.7	424
0B98-13	10.2	8.0 - 9.3	230
OB99-25	17.1	8.0 - 9.3	133
OB99-26	19.8	9.3 - 10.7	295
OB99-26	19.8	16.7 - 18.0	634
OB99-36	11.0	2.7 - 4.0	44
OB99-36	11.0	4.0 - 5.3	43
OB99-37	18.9	2.7 - 4.0	85
OB99-41	11.3	2.0 - 2.7	550
OB99-42	11.3	5.3 - 6.7	57
OB99-58	>19.2	2.7 - 4.0	135
OB00-63	6.9	4.0 - 5.3	451
OB00-65	14.7	6.7 - 8.0	180
OB00-66	6.9	4.0 - 5.3	180
OB00-73	26.4	4.0 - 5.3	478
OB00-74	26.7	3.3 - 4.7	908
OB00-75	14.0	8.0 - 9.3	257

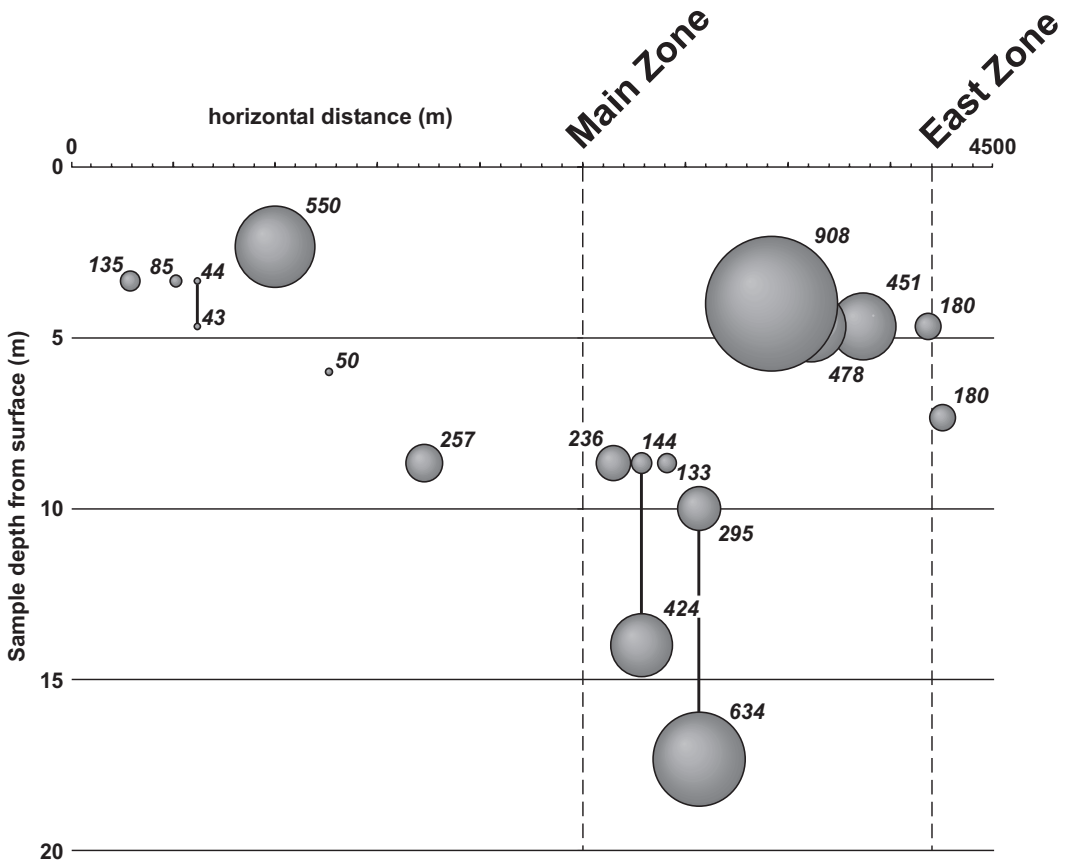

Figure 5. Becker Hammer borehole samples analysed to date, plotted with depth and distance from known mineralization (i.e. Main and East Zones). Diameter of data point is proportional to copper concentration; labels are actual copper values (ppm). Samples from the same borehole are connected with a solid line.

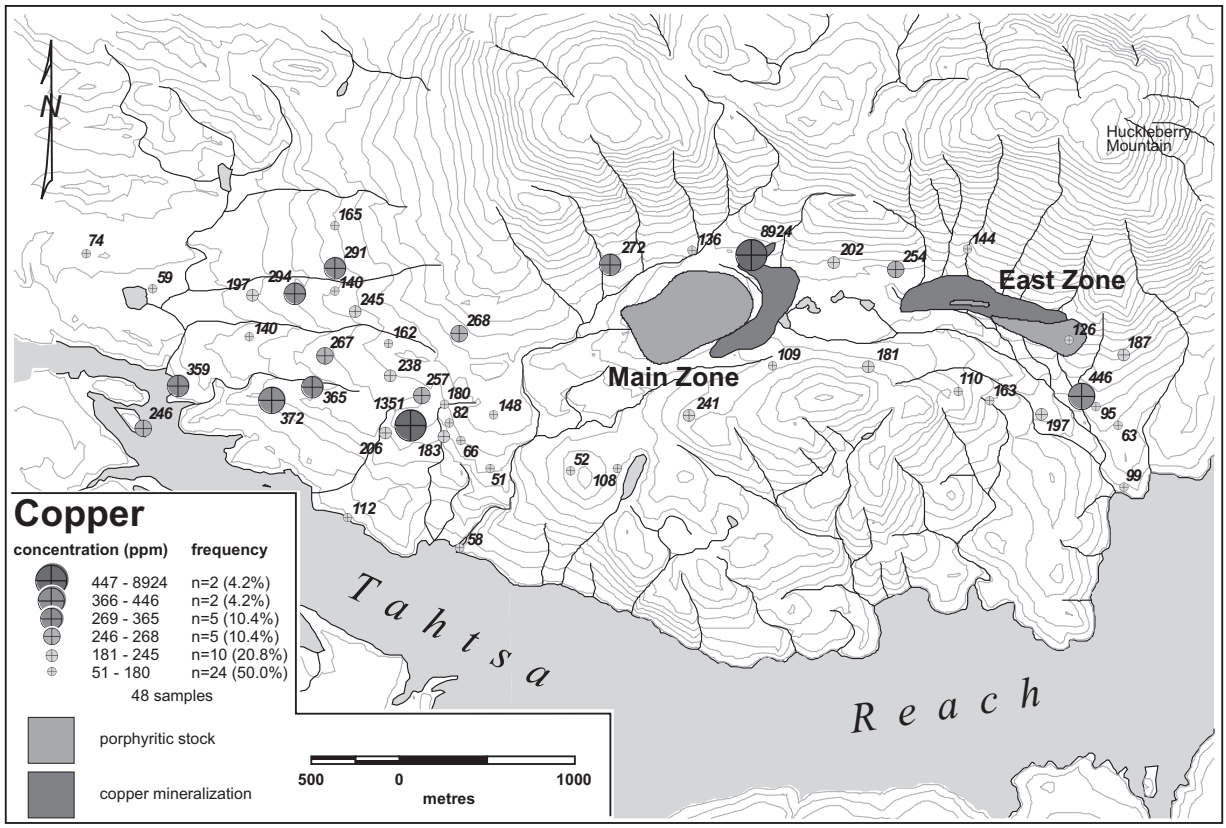

Figure 6. Gradational symbol map of routine surface samples analyzed to date. Samples are labelled with actual copper values (ppm).

ure 6). These data are suggestive of westerly dispersal and in general support the evidence from ice flow indicators indicating a strong westerly flow event in the region. However, generally low concentrations of copper in tills from bore holes in the western part of the Huckleberry Mine property (Figure 4 and Table 1; *e.g.* 43, 44, 50, and 85 ppm) may reflect early easterly transport of till from non-mineralized areas to west. Preliminary results of stratigraphic and lithologic analysis of tills, well exposed in borrow pits in this area, support this interpretation.

Indications of Undiscovered Mineralization

The copper content of surface tills close to the East and Main zones is relatively low in comparison with an area on the west side of the property about 2 to 3 kilometres west of the Main Zone (Figure 6). Five sites in this area exceed the 80th percentile (268 ppm) and the second highest copper content encountered in till to date in the region (1351 ppm) occurs at a sixth site in this same area. The latter site occurs at the crest of a till ridge and it is therefore unlikely that the high copper there is a result of hydromorphic dispersion. Also, several clasts with chalcopyrite mineralization were observed in the till at this site, one yielding an assay of 0.62% Cu. Two samples taken along a bush traverse to the west of this site also yielded high copper values (365 and 372 ppm; Figure 6) and mineralized erratics. In contrast, several surface till samples located to the east of this site yielded copper concentrations near or below the area median.

These data are suggestive of a west-trending dispersal plume with an apex at or around the 1351 ppm copper sample site. Copper values decrease from 372 to 246 ppm to the west of this site over a distance of 1.5 kilometres. To the east, copper values abruptly drop from 183 to 66 ppm copper, over a distance of 250 metres. Although it is possible that these data could represent dispersal from the Main Zone, a number of factors suggest that there may be an undiscovered bedrock source for the mineralization near the high copper till site. These factors include: the relatively long distance of the anomalous tills from the Main Zone (about 2 kilometres); the high concentration of copper (1351 ppm) in till at the one site; and the sharp decrease in copper to the east of that site. It is also possible that the source of the copper in the tills could be mineralized volcanics located under the tailings pond (approximately 750 metres to the east). However, a more optimistic target occurs directly north of the till site with the 1351 ppm copper, in a low swampy area that is geomorphologically similar to the poorly drained areas that originally obscured much of the Main and East zones. Further work is required to determine the location, extent and grade of the bedrock source for the high copper in tills on the west side of the property.

Comparison of Huckleberry Tills with Other Areas

The median copper concentration of till in the Huckleberry area (181 ppm) is considerably higher than median values obtained in detailed studies around copper porphyry deposits at the Nak property (66 ppm, Levson *et al*., 1997) and the Bell Mine (MINFILE No. 093M 001) (63 ppm, Stumpf *et al*., 1997) and could be attributable to differences in the lithology of the host rocks or the type of mineralization. At the Bell Mine, for example, mineralization is hosted mainly in a biotite-feldspar porphyry whereas at Huckleberry mineralization is mainly within the country rocks (andesites).

In contrast with findings at the Nak property where copper concentrations in most holes varied little with depth (generally less than 50 ppm, Levson *et al*., 1997), there is significant variance in copper concentrations with depth at Huckleberry Mine. This is clearly illustrated between the Main and East zones in Figure 5 where elevated values of 180-908 ppm found at 2 to 5 metres depth and 424 to 634 ppm at 14 to 17 metres depth, are separated by relatively low values of 133-295 ppm from 7 to 10 metres depth. As well, Figure 5 illustrates that in the borehole samples copper concentrations generally decrease away from known mineralization with the lowest concentrations generally occurring farthest west. This pattern however, is observed with a data set of only 18 samples and interpretations should be viewed with caution. Of particular interest, are two sites at the east end of the East Zone (sites OB00-65 and OB00-66, Figure 4). These samples were taken between 4 and 8 metres depth and both have relatively low copper concentrations of 180 ppm (Table 1). Since these sites lie to the east of copper mineralization in both the East and Main zones, it seems unlikely that the till there was deposited by ice flowing to the east. Westerly flow is also supported by the high copper content in till at sites OB00-63, OB00-73 and OB00-74, to the west of these two sites (Figures 4 and 5).

The geochemical results and interpretations presented here are preliminary. More geochemical analyses are needed before dispersal plumes, and their two and three-dimensional geometry, can be thoroughly investigated, and before the potential effects of a change in ice flow direction from west/southwest to east/northeast in the Huckleberry Mine area can be determined.

SUMMARY

Preliminary analyses of ice flow data indicate that glaciers early in the Fraser Glaciation, sourced in high elevation areas in the Coast Mountains, flowed easterly through the Huckleberry Mine area into the Nechako Plateau, but west to southwest ice flow dominated in the region during the glacial maximum. This latter event was regionally significant as there is clear evidence of west to southwest ice flow across mountain peaks above elevations of 1500 metres in the Huckleberry region, and across high mountain ranges elsewhere in the western part of the Nechako Plateau. The source of ice for this event was an ice dome(s) east of the study area in central British Columbia, which formed a migrating ice divide(s). Towards the end of the Late Wisconsinan this divide locally shifted west back towards the Coast Mountains, probably as the ice sheet that covered west-central British Columbia began to thin. As a result, in some areas such as in the region east of the Huckleberry mine, ice flow directions reversed and glaciers again flowed east and northeast from the Tahtsa Ranges out into the Nechako Plateau.

Geochemical analyses conducted to date in the Huckleberry mine area show significant variance both laterally and in vertical profile, in elemental concentrations of basal tills. Preliminary results indicate that copper concentrations in basal till decrease with increasing distance from known mineralization and are consistent with westerly dispersal in most cases. This relationship is observed in both bore hole samples and in routine surface samples although there are some indications of early easterly dispersal in the region. Also of interest is an area of anomalous copper (>80th percentile) in surface till samples on the west end of the Huckleberry Mine property. Copper concentrations there gradually decrease west of a site with the second highest copper value (1351 ppm) in till encountered in the study area to date. Copper concentrations in till east of this site, closer to the Main Zone, are relatively low suggesting the presence of a westerly directed dispersal plume. Although the source of mineralization for this dispersal plume could be mineralized volcanics under the tailings pond (approximately 750 metres east), or possibly even the Main Zone further (~2 kilometres) to the east, the data is suggestive of an as yet unidentified source closer to the till anomaly.

The results and interpretations presented here are preliminary. Further analyses on striae data, fabric measurements, and pebble counts are required to refine the ice flow model presented for the Huckleberry Mine property. More geochemical analyses are also needed before dispersal plumes, and their two and three-dimensional geometry, can be thoroughly investigated, and before the effects of a shifting ice divide in the Huckleberry Mine area on geochemical dispersal in till, can be fully determined.

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