Quaternary Geology and Till Geochemistry of the Nadina River Map Area (NTS 093E/15), West-Central British Columbia

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Introduction

The Tahtsa Lake district has high potential to host new porphyry Cu±Mo and polymetallic vein-style mineralization (including Au). Centred on Tahtsa Lake (approximately 100 km south of Houston, British Columbia; Figure 1), this district, and areas immediately adjacent to it, have a rich mineral exploration history and at present host a producing porphyry Cu-Mo mine (Huckleberry mine) and numerous developed Cu±Mo prospects (e.g., Berg, Lucky Ship; MacIntyre, 1985). This district also hosts epithermal and perhaps volcanogenic massive sulphide–style mineralization, and polymetallic veins, as suggested by past producers such as Equity Silver and Emerald Glacier (MacIntyre, 1985; MacIntyre et al., 2004; Alldrick et al., 2007; Figure 2). Currently there are large areas of unstaked ground within, and adjacent to, the northern portion of the Tahtsa Lake district. Much of this area is covered with glacial drift and continuous bedrock outcrop is limited to the higher peaks and their steep flanks. Till geochemical surveys are an effective method for assessing the metallic mineral potential of areas covered with glacial drift and are ideally suited to assessing the potential for new mineralization in this area. Till geochemical surveys are also well suited for following up on airborne geophysical data recently acquired by Geoscience BC for the QUEST-West Project area (Kowalczyk, 2009), where drift can cover anomalous bedrock.

A two-year Quaternary geology and till geochemistry program is currently underway within the northern portion of the Tahtsa Lake district and adjacent areas (NTS map areas 093E/15, /16, 093L/01, /02; Figure 2). The objectives of this program are to

1) characterize and delineate the Quaternary materials that occur in the study area and reconstruct the region's ice-flow history; and
2) assess the economic potential of covered bedrock (subcrop) by conducting a till geochemistry survey.

Keywords: *till geochemical survey, trace-element geochemistry, heavy minerals, gold grain counts, porphyry Cu, polymetallic vein, Tahtsa Lake district*

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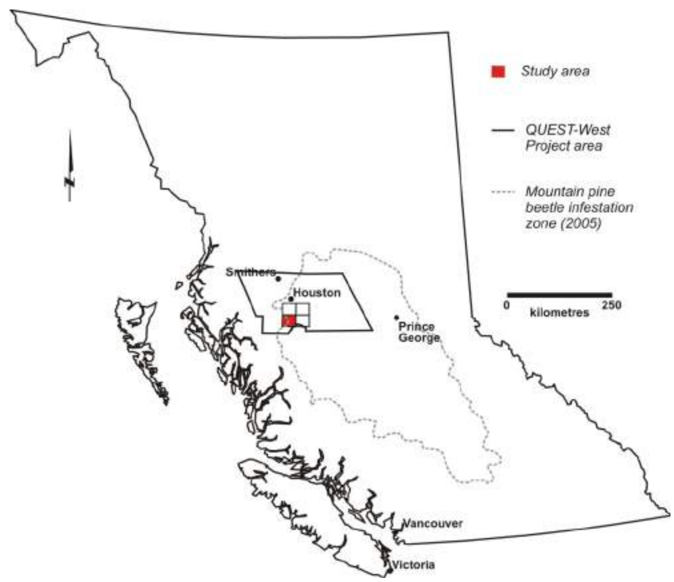

Figure 1. Location of study area in west-central British Columbia.

The study area falls within the mountain pine beetle–impacted zone and Geoscience BC's QUEST-West Project area. The goal of this project is to provide high-quality, regional-scale, geochemical data to the mineral exploration community that will help guide exploration efforts. Integrating interpretations of these data with other geochemical and geophysical data being collected by Geoscience BC in the QUEST-West Project area, and historic data that have been collected by the British Columbia Geological Survey (BCGS) and the Geological Survey of Canada (GSC), will provide a powerful tool for companies exploring in this drift-covered area.

The focus of this paper is surficial geology mapping, and the sampling component of a till geochemical survey, completed within the Nadina River map area (NTS 093E/15) during the 2009 field season.

Study Area

The study area is located in west-central BC, approximately 100 km southwest of Houston, in NTS map area 093E/15 (Figures 1, 2). It is accessible by Forest Service, private and

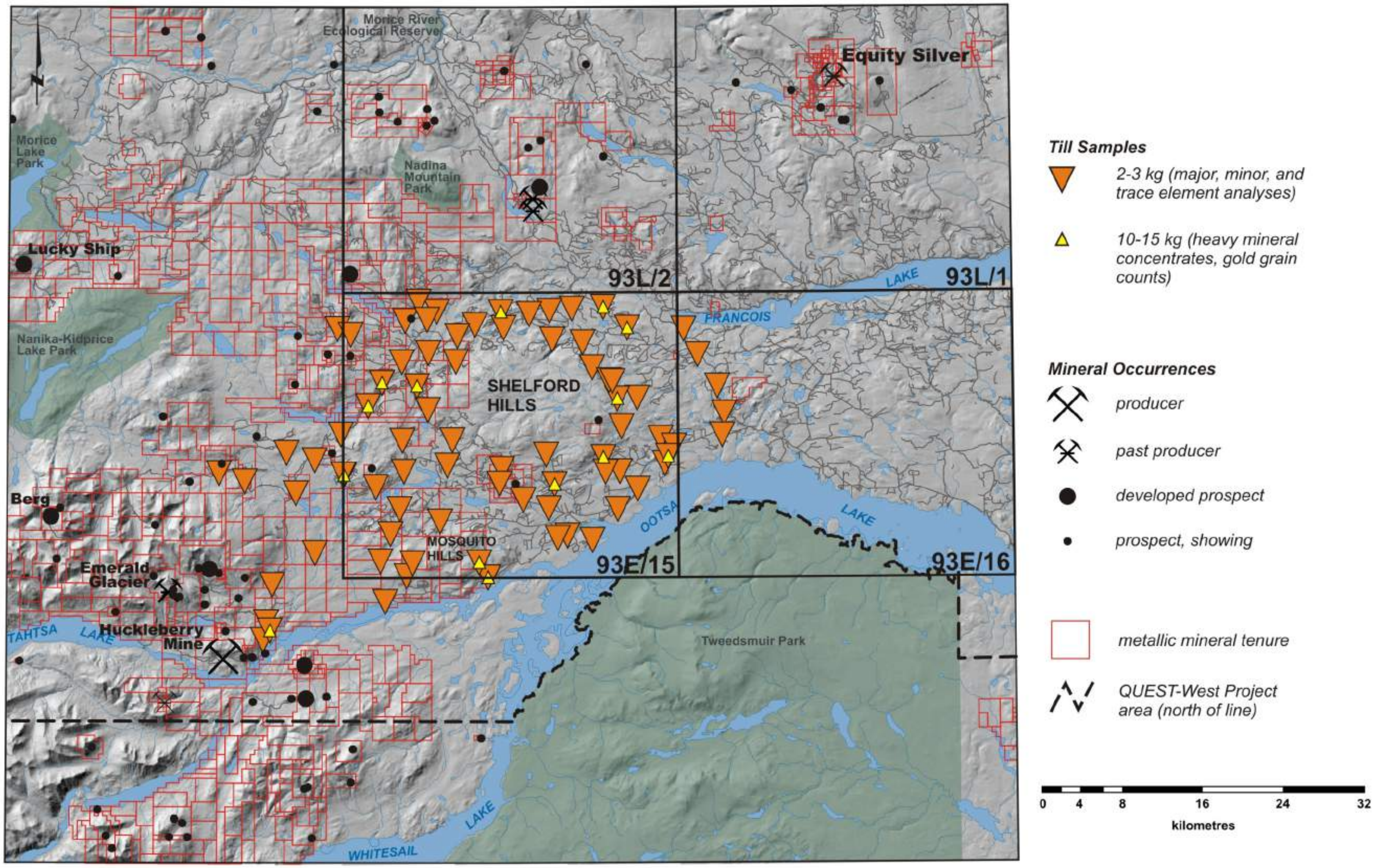

Figure 2. Locations of till samples within the Nadina River map area (NTS 093E/15), British Columbia. Additional samples were collected outside the map area to take into account possible east and/or west transport.

abandoned mine and mineral exploration roads. The majority of the study area is situated in the Nechako Plateau, a subdivision of the Interior Plateau. The Nechako Plateau is an area of low relief with flat or gently rolling topography (Holland, 1976), most of which is covered by a thick package of glacial sediments (Figure 3). Although bedrock outcrop is relatively uncommon, some exposures can be found at the stoss (i.e., up-ice) end of crag-and-tail forms, along lake shorelines, on higher ground within Shelford and Mosquito hills, and on local small-scale erosional remnants that stand above the plateau surface to the west and northwest of Shelford Hills. The very southwest corner of the study area is situated in the Tahtsa Ranges (Holland, 1976), a northwest-trending belt of nongranitic mountains.

Bedrock Geology

The Tahtsa Lake district lies within the Stikine Terrane, just east of the Coast Crystalline Belt (Monger et al., 1991). The west half of the study area is underlain mainly by Early to Middle Jurassic Hazelton Group volcanic and sedimentary rocks (MacIntyre, 1985). In places, these rocks are unconformably overlain by Middle to Late Jurassic Bowser Lake Group marine sedimentary rocks and Early Cretaceous Skeena Group turbidites and local basalt flows. These rocks are in turn unconformably overlain by felsic pyroclastic rocks, felsic flows and younger basaltic flows of the Early to Late Cretaceous Kasalka Group volcanic rocks. Many small- to medium-sized, Late Cretaceous to Early Tertiary stocks have intruded these volcanic piles and sedimentary packages (MacIntyre, 1985). The east half of the study area is dominantly underlain by Late Cretaceous to Tertiary Ootsa Lake Group and Eocene Endako Group volcanic rocks. There is a strong correlation between the location of intrusive rock types (in particular, porphyritic intrusions like those of the Late Cretaceous Bulkley suite) and the locations of Cu, Mo, Au, Pb, Zn and Ag mineralization (Carter, 1981; MacIntyre, 1985).

Figure 3. Subdued topography of the southwest corner of the study area, British Columbia. View is towards the east with Mosquito Hills in the background.

Quaternary Geology

Till is the dominant surficial material type within the study area. In lower valley settings, and on hill flanks, it occurs as thick units (>2 m thick) that typically overlie glacially eroded bedrock. In high elevations, it occurs as thinner veneer units (<1 m thick) that are closely associated, and discontinuous, with colluvium and bedrock. The surface expression of till most often conforms to underlying bedrock topography but also can be streamlined, as seen in the drumlinized and fluted terrain between the south and southeast flank of Shelford Hills and the northern shore of Ootsa Lake.

Glaciofluvial sand and gravel can also be found within the study area. They occur in fan-like features at the mouths of gulleys that head in higher ground such as Shelford and Mosquito hills. They also occur within late-glacial to deglacial drainage systems (now abandoned) as outwash plains and esker-like ridges. Glaciolacustrine and lacustrine sediments only rarely occur within the study area. Thick organic units are, however, common along the shorelines of smaller lakes and in low-lying areas that separate these smaller lakes when they occur in chains.

Ferbey and Levson (2001a, b, 2007) built on previous work by Stumpf et al. (2000) that indicated there was an ice-flow reversal in west-central BC during the Late Wisconsinan glacial maximum. During the onset of glaciation, ice flowed radially from accumulation centres, such as the Coast Mountains, towards central BC. Sometime during the glacial maximum, however, the ice divide over the Coast Mountains migrated east into central BC resulting in an ice-flow reversal. Glaciers were now flowing west across some parts of the western Nechako Plateau (including the study area), over the Coast Mountains and towards the Pacific Ocean. Eastward ice flow resumed once the ice divide migrated back over the axis of the Coast Mountains, and continued until the close of the Late Wisconsinan glaciation.

Evidence for this ice-flow reversal in the Huckleberry mine region is seen in macro-scale glacial landforms (e.g., crag-and-tail forms, roches moutonnées) and micro-scale ice-flow indicators (e.g., rat tails, roches moutonnées) on bedrock outcrop in valley bottoms and at higher elevation sites (i.e., >1500 m asl). This ice-flow reversal is also detectable in trace-element till geochemical data from Huckleberry mine (Ferbey and Levson, 2007).

Previous Work

Directly south and adjacent to the study area, Ferbey and Levson (2001a, b, 2003, 2007) and Ferbey (2004) conducted a detailed study of the Quaternary geology and till geochemistry of the Huckleberry mine region. These studies demonstrate a clear relationship between till samples elevated in Cu, Mo, Au, Ag and Zn and the Cu-Mo ore zones at Huckleberry mine and smaller-scale polymetallic vein occurrences on the mine property. Lateral and vertical variability in trace-element concentrations in till at Huckleberry mine provide further evidence for an ice-flow reversal in the region during the Late Wisconsinan glacial maximum (Ferbey and Levson, 2007). These results suggest that interpreting trace-element geochemical data from tills or soils in this region can be complex, in particular when considering transport direction.

Plouffe and Ballantyne (1993), Plouffe (1995), Plouffe et al. (2001) and Levson and Mate (2002) have also conducted till geochemistry surveys to the east of the study area, in NTS map areas 093F and K. Using percentile plots of precious-metal, base-metal, and pathfinder element concentrations, and/or gold grain counts, each of these surveys identifies prospective ground where there are no known mineral occurrences.

Methods

Surficial Geology Mapping and Reconstruction of Ice-Flow History

Surficial geology mapping will be completed for each of the four map sheets in the study area. This mapping will be conducted at 1:50 000 scale using aerial photographs (1:40 000 scale black and white), digital orthophotographs and other available remotely sensed imagery (e.g., Landsat). An integral part of this component is the reconstruction of the region's ice-flow history using macro-scale landforms (e.g., drumlins, flutes, crag-and-tail forms) and outcrop-scale glacial features, such as striations, rat tails and roches moutonnées. Surficial geology mapping will characterize and delineate Quaternary materials occurring within the study area and the reconstructed ice-flow history will be used to determine the transport direction of glacial sediments. The efficiency and effectiveness of till sampling, and interpretation of resultant geochemical data, will be increased by knowing where basal till is likely to occur and the direction it was transported. Surficial geology mapping is currently in progress for NTS map area 093E/15.

Basal Till Sampling

Till geochemical surveys can detect known sources of mineralization and identify new geochemical exploration targets (e.g., Levson et al., 1994; Cook et al., 1995; Sibbick and Kerr, 1995; Plouffe, 1997; Levson, 2002; Ferbey, 2009). Till geochemical surveys are well suited to assessing the mineral potential of ground covered by glacial drift. Basal till, a specific type of drift and the sample medium used in these surveys, is ideal for these assessments as it has a relatively simple transport history, is deposited directly down-ice of its source, and produces a geochemical signature that is areally more extensive than its bedrock source and therefore, at a regional-scale, can be more easily detected (Levson, 2001). The area under investigation as part of this study is thought to fall within the area affected by the Late Wisconsinan ice-flow reversal (Ferbey and Levson, 2001a, b, 2007). Its influence on the transport direction of basal tills was taken into consideration when designing and implementing the till geochemical survey component of this program.

During the 2009 field season, 2–3 kg till samples were collected at 84 sample sites for major, minor and trace-element geochemical analyses (Figures 2, 4). An additional 16 till samples, each weighing 10–15 kg, were collected for heavy mineral separation and gold grain counts (Figure 2). These larger samples were collected at sites where an adequate amount of sample material was exposed. Given that net transport direction in the study area was likely affected by an ice-flow reversal during the Late Wisconsinan glacial maximum, till samples were collected outside of NTS 093E/15 to take into account possible east and/or west transport of basal till. Till sample density for this survey is one sample per 14 km^2. For simplicity, areas inaccessible by truck (e.g., Shelford Hills), and areas where till does not occur, were included in this calculation.

Till samples collected for major, minor and trace-element analyses are being sieved, and decanted and centrifuged to produce a silt- plus clay-sized (<0.063 mm) and clay-sized (<0.002 mm) fraction. This sample preparation is being conducted at Acme Analytical Laboratories Ltd. (Vancouver, BC). Heavy mineral samples have been sent to Overburden Drilling Management Limited (ODM; Nepean, ON), where heavy mineral (0.25–2.0 mm) and gold grain (<2.0 mm) concentrates are being produced using a combination of gravity tabling and heavy liquids.

On the 2–3 kg samples, minor and trace-element analyses (37 elements) will be conducted on splits of the silt- plus

Figure 4. Typical sample site in a roadcut, west-central British Columbia. In the foreground is a 2–3 kg sample.

clay- and clay-sized fractions, respectively, by inductively coupled plasma–mass spectrometry (ICP-MS), following an aqua-regia digestion. Major element analyses will be conducted on a split of the silt- plus clay-sized fraction only using inductively coupled plasma–emission spectrometry (ICP-ES), following a lithium metaborate/tetraborate fusion and dilute nitric acid digestion. This analytical work will be conducted at Acme Analytical Laboratories Ltd. (Vancouver, BC).

Also as part of this project, a split of the silt- plus clay-sized fraction will be analyzed for 35 elements by instrumental neutron activation analysis (INAA) at Becquerel Laboratories Inc. (Mississauga, ON). Instrumental neutron activation analyses for elements such as Au, Ba and Cr complement those produced by aqua-regia digestion followed by ICP-MS as they are considered to be a near-total determination and hence more representative of rock-forming and economic mineral geochemistry. Additionally, INAA determinations will be conducted on bulk heavy mineral concentrates produced from the 10–15 kg samples. Heavy mineral picking, scanning electron microscope (SEM) analyses on difficult-to-identify heavy mineral grains, and pebble counts may be conducted on these samples at a later date. Results from INAA will dictate for which samples, if any, these additional and costly analyses are warranted.

Quality Control

Quality control measures for analytical determinations include the use of field duplicates, analytical duplicates and reference standards. For each block of 20 samples submitted for analysis, one field duplicate (taken at a randomly selected sample site), one analytical duplicate (a sample split after sample preparation but before analysis) and one reference standard will be included in INAA and ICP-MS analysis. Reference standards used will be a combination of certified Canada Centre for Mineral and Energy Technology (CANMET) and in-house BCGS geochemical reference materials. Duplicate samples will be used to measure sampling and analytical variability, whereas reference standards will be used to measure the accuracy and precision of the analytical methods.

Upcoming Data Releases and Future Work

Till geochemical data for the Nadina River map area (NTS 093E/15) will be the topic of a combined BCGS Open File and Geoscience BC Report to be released in late spring 2010. This report will present data from the geochemical survey discussed here, including interpretations of these data in the context of metallic mineral exploration and the region's complex ice-flow history.

Field crews will return to the study area during the 2010 summer field season and complete data collection for the Wistaria, Colleymount and Owen Lake map areas (NTS 093E/16, L/01, /02). The methods used to complete this work will be the same as those presented in this report for the Nadina River map area (NTS 093E/15).

Summary

The 2009 field season saw the completion of fieldwork for year one of a two-year Quaternary geology program that is designed to assess the mineral potential of the northern portion of the Tahtsa Lake district and adjacent areas (NTS 093E/15, /16, 093L/01, /02). This study area falls within Geoscience BC's QUEST-West Project area where additional geochemical data have been compiled and collected, mineral occurrence data (i.e., MINFILE, 2009) have been updated, and helicopter-borne time domain electromagnetic and gravity data have been acquired. The focus of this year's work is the Nadina River map area (NTS 093E/15) where 84 samples of basal till, each weighing 2–3 kg, were collected for major, minor and trace-element geochemical analyses, and an additional 16 till samples, each weighing 10–15 kg, were collected for separation and analysis of heavy mineral concentrates and gold grain counts. Ongoing and complementary to this till geochemical survey, is 1:50 000 scale surficial geology mapping and a regional ice-flow study. Given that the study area experienced an ice-flow reversal during the Late Wisconsinan glacial maximum, assessing and quantifying net transport direction of basal till in the study area will be a significant contribution to the understanding of detrital dispersion for the region. An understanding of these variables must exist prior to further investigation of any till samples, collected as part of this study, that are elevated in an element(s) of interest. An assessment of net transport direction will also be of interest to mineral exploration companies working in the area, who are conducting their own surficial sediment geochemistry surveys.

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