Quaternary Geology and Till Geochemistry of the Bulkley River Valley, West-Central British Columbia (part of NTS 093L)

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Stumpf, A.J. (2011): Quaternary geology and till geochemistry of the Bulkley River valley, west-central British Columbia (part of NTS 093L); *in* Geoscience BC Summary of Activities 2010, Geoscience BC, Report 2011-1, p. 57–64.

Introduction

Mineral exploration by traditional exploration techniques has been hindered in central British Columbia because of a thick and nearly continuous cover of glacial sediments masking the bedrock surface. The bedrock in the region has a high mineral potential with several active mines and past producers. Regional till geochemistry surveys have been used to determine the background mineral composition and identify anomalous concentrations that can be traced to bedrock sources. The geochemical composition of till is directly influenced by the bedrock geology and dominant direction of glacier flow during the last glaciation (Late Wisconsinan).

To assist the mining industry in locating new mineral prospects, a till geochemistry survey and associated till pebble collection was undertaken in the Bulkley River valley and adjacent areas (Figure 1). The data was collected for the British Columbia Geological Survey (BCGS) in 1996, as part of a larger regional till sampling and surficial geology mapping project in the Babine Lake valley area of west-central BC. The BCGS project was a component of a program of multidisciplinary and collaborative research with the Geological Survey of Canada (GSC), universities and the mining industry under the Nechako National Geoscience Mapping Program (NATMAP) in central BC. This Bulkley River valley data has not been published and its release now would provide information about the background geochemistry and Quaternary geology of this part of west-central British Columbia, information that is not currently available.

A two-year Geoscience BC–funded project is under way to deliver the till geochemical and pebble lithology data for Bulkley River valley and adjacent areas (encompassing parts of NTS map areas 093L/07, /08, /09, /10, /11, /15; Figure 2). This project is being undertaken in an area that is within Geoscience BC's QUEST-West Project area and the Mountain Pine Beetle–Impacted Zone.

Keywords: *geochemistry, till, Quaternary geology, mineral exploration, QUEST-West Project*

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The objectives of this study are three-fold:

- publish existing till geochemical and pebble lithology data;
- determine the background geochemical composition of till in an area having a high mineral potential; and
- identify glacial dispersal trains originating from buried (subcropping) bedrock by analyzing the distribution of above background (anomalous) geochemical and pebble lithology compositions.

The goal of this project is to provide the mineral exploration community additional information characterizing the glacial materials, which in this region form a near-continuous cover masking the bedrock surface. Combined with existing geological and geophysical data collected by Geoscience BC, and historical databases archived at the BCGS and GSC, this information will assist companies to identify new exploration targets and re-evaluate known mineral occurrences. These activities will promote further investment in the resource exploration and development sector in this part of BC.

Study Area

The study area is located in west-central BC approximately 340 km east of Prince Rupert and 400 west of Prince George (Figure 1), and centred along the Bulkley River valley from its headwaters, located west of Houston (NTS 093L/07), northwest to the town of Smithers (NTS 093L/14). The area can be accessed from the Yellowhead (Trans-Canada) Highway 16 along an extensive system of Forest Service, provincial highways, municipal and/or farming roads.

This area of west-central BC is characterized by broad U-shaped drift-filled valleys, bordered by glacially rounded mountains, with only a few jagged peaks emerging from the highest mountains. The southern two-thirds of the study area, including much of the Bulkley River and Babine Lake valleys, lie within the Nechako Plateau physiographic subdivision of the Interior Plateau (Holland, 1976). The Nechako Plateau is characterized by a rolling to undulating

Figure 1. Location of study area in west-central British Columbia. The grid of 1:250 000 scale NTS map sheets is overlain on the map. The study area is delineated by the red shading.

topography that lies at an average elevation of 1200 m asl. The Bulkley River valley is bordered to the north and south by the Skeena and Hazelton mountains, respectively. The Skeena Mountains average 1600 m asl north of Houston and rise steeply to over 2100 m asl northwest of the town of Smithers (Figure 2). The Bulkley, Telkwa and Hudson Bay ranges of the Hazelton Mountains lie south of the valley and reach elevations over 2300 m asl. Glaciers and icefields occupy the north-facing cirques. The Morice and Telkwa River valleys drain these mountains to the Bulkley River, which flows north to the Skeena River and on to the Pacific Ocean. Babine Lake drains south and then east and lies within the Fraser River watershed. A low divide constructed of glacial sediments separates the Skeena River and Fraser River watersheds along the eastern boundary of the study area. In places, glacial meltwater streams have cut narrow channels across the divide. These meltwater streams drained glacial lakes that formed in the Bulkley River and Fraser River valleys (Plouffe, 2000; Stumpf et al., 2004).

Quaternary Geology

Except during earlier mapping of the bedrock geology where notes were made on glacial landforms and features (e.g., Tipper and Richards, 1976), mapping of glacial sediments in the study area was not conducted until the early 1980s (Clague, 1984). Only the surficial materials and glacial landforms lying in the Bulkley River valley between the village of Telkwa and town of Smithers below 1220 m asl were mapped as part of this project. Additional mapping was undertaken in other parts of the study area from 1995 to 1997 as part of the Nechako NATMAP. Stumpf (2001) and Stumpf et al. (2004) described in detail the glacial sediments exposed in outcrops along the Bulkley, Morice and Telkwa rivers. Levson et al. (1998), Stumpf et al. (2000) and Stumpf (2001) mapped the promi-

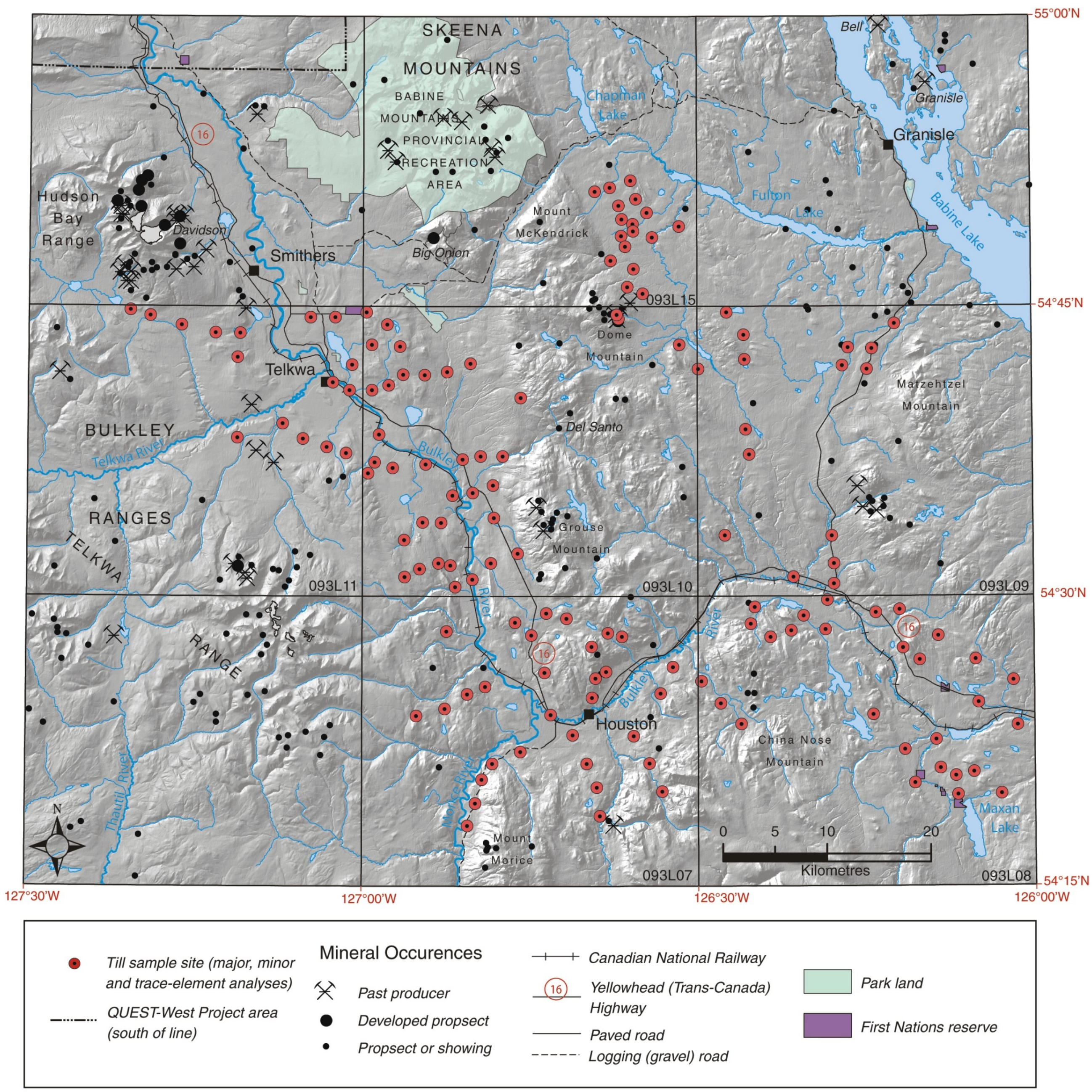

Figure 2. Overview of the Bulkley River project area in west-central British Columbia. Till sample locations are denoted by the red dots. The grid of 1:50 000 scale NTS map sheets is overlain on the map. Mineral occurrences were plotted from the MINFILE BC mineral deposits database (BC Geological Survey, 2008).

nent glacial landforms and erosional features (e.g., striae, flutings, rat tails) found in the Bulkley River valley and on the adjacent uplands. The surficial geology of the NTS 093L/09 map area was compiled by Levson (2002) as part of geological studies conducted in the Babine Lake area.

Thick deposits of till, glacial lake and glaciofluvial sediments infill the major valleys. Borehole logs recorded during drilling of water wells, engineering structural borings and exploration testholes suggest that >50 m of glacial sediments are present in the deepest part of the Bulkley River valley (Stumpf, 2003). Glacial lake sediments cap these deposits in some valleys at <750 m asl (Stumpf et al., 2004). Outside of the valleys, above approximately 1050 m asl, a discontinuous veneer or blanket of till is present on the bedrock surface.

Ice-Flow History

Stumpf et al. (2000), Stumpf (2001) and Levson (2002) provide a detailed discussion of the ice-flow history of the

Bulkley River area. The chronology of glacier flow events was built from suggested ice-flow histories (e.g., Clague, 1984; Plouffe, 1991; Tipper, 1994). This was advanced further by the interpretations made from ice-flow indicators, which included measuring the orientation of streamlined landforms (such as drumlins, crag-and-tail ridges and flutings mapped from aerial photographs) and the orientation, crosscutting pattern and degree of preservation of striations, rat tails and grooves on bedrock outcrop. Three main phases of ice flow have been recognized in the study area from interpretation of the ice-flow indicators. At the onset of glaciation, cirques and valley glaciers expanded from accumulation centres in the Skeena and Hazelton mountains and flowed west along the Bulkley River valley into the Skeena River valley and south and east on to the Nechako Plateau. At this time, the direction of glacier flow was controlled primarily by uplands bordering the valleys. Upon further accumulation, expansion and thickening of the ice, the glaciers eventually formed a single (Cordilleran) ice sheet. At its maximum extent, the ice sheet reached a thickness over 2000 m, at which time the centres of accumulation had shifted to the east of the study area over the Nechako Plateau. This reconfiguration in the ice sheet caused a major reversal in glacier flow across the study area. The ice sheet was able to flow unobstructed, above major topographic barriers in the Skeena and Hazelton mountains. Subsequently, glacier flow was from east to west across the Bulkley River valley, away from ice centres located further inland, then across coastal mountains to the Pacific Ocean. This reversal continued well into the glaciation period until the drawdown of the ice lowered the surface of the glaciers below topographic barriers in the Skeena and Coast mountains. At this time, the centres of growth shifted west to the Skeena and Hazelton mountains causing the pattern of glacier flow to shift back to the configuration of the early (advance) glacial phase. These reversals are not only recognized by mapping ice-flow indicators, but also by the pattern of glacial transport determined from till geochemistry surveys and tracing erratics back to the bedrock source (Stumpf et al., 2000; Ferbey and Levson, 2001, 2010).

Bedrock Geology

The Bulkley River area lies entirely within the Stikine terrane of the morphogeological Intermontane Belt, just east of the Coast Belt (Gabrielse et al., 1991). The bedrock geology in the NTS 093L map area was first described and mapped by Armstrong (1944), and later revised by Tipper and Richards (1976). Additional geological mapping and data compilation has been conducted (e.g., MacIntyre et al., 1987; Massey et al., 2003; Struik et al., 2007) to update the geological units and tectonic setting. Recent mapping, supported by Geoscience BC, in Bulkley River valley and adjacent areas was focussed on compiling existing data on Skeena Group and Bowser Basin rocks (MacIntyre, 2006; Evenchick et al., 2008).

The study area is underlain by Middle to Late Triassic, Early to Middle Jurassic volcanic, volcaniclastic and related marine sedimentary rocks of the Takla and Hazelton groups (MacIntyre, 2006). Locally, these rocks are unconformably overlain by Late Jurassic to Early Cretaceous marine to nonmarine sedimentary rocks of the Bowser Lake and Skeena groups, which were deposited along the southeastern margin of the Bowser Basin (MacIntyre, 2006; Alldrick et al., 2007). Over the western half of the study area, Late Cretaceous to early Eocene volcanic and related pyroclastic and volcaniclastic rocks unconformably overlie rocks of the Stikine terrane and Bowser Basin (MacIntyre, 2006). From Houston to the southeast, the Stikine terrane is unconformably overlain by Early Eocene basalt and flows with related pyroclastic rocks of the Endako Group. These stratified rocks are cut by four plutonic suites (Topley, Bulkley, Babine and Nanika) associated with major magmatic events that occurred during the Early Jurassic, Late Cretaceous and Eocene. Most of the mineral deposits in the study area are related to the Late Cretaceous Bulkley and Eocene Babine and Nanika suites (Carter, 1981; MacIntyre, 2006). The most economically important deposit types associated with these intrusions are the following:

- epithermal and polymetallic veins – intrusions outcropping on Grouse and Dome mountains;
- porphyry Cu±Mo±Au deposits – Bell past producer (MINFILE 093M 001; BC Geological Survey, 2010), Granisle past producer (MINFILE 093L 146) and Big Onion developed prospect (MINFILE 093L 124), all shown on Figure 2; and
- low F-type porphyry Mo deposits – Davidson developed prospect (MINFILE 093L 110; Figure 2).

In addition, Eskay Creek–type subvolcanic Cu-Ag-Au-(As-Sb) deposits (Del Santo prospect [MINFILE 093L 025; Figure 2]) have been recognized as potential target areas for further exploration. The most prospective rocks for discovery of this type of deposit include Middle Jurassic submarine volcanic rocks of the Hazelton Group (Massey et al., 1999) and mid-Cretaceous bimodal volcanic rocks of the Rocky Ridge Formation (MacIntyre and Villeneuve, 2001; Alldrick et al., 2007).

Previous Work

Regional- and property-scale till geochemistry surveys were undertaken adjacent to and directly east and south of the study area (Plouffe, 1995; Ferbey and Levson, 2001, 2010; Levson, 2002; Ferbey et al., 2009; Ferbey, 2010). These studies have found a direct correlation with the mineralogy and lithology of till and mineralized bedrock found up-ice. In addition to determining the background elemental composition of till, in some areas, the direction and maximum distance of glacial transport was determined based upon the location of geochemical anomalies, direction of glacier flow and till thickness (Plouffe, 1995; Levson, 2001; Ferbey and Levson, 2010).

Till Sample Collection

In 1996, as part of till geochemistry and Quaternary geology studies in the Babine Lake area in support of the Nechako NATMAP in central BC, a till sampling project was undertaken in the Bulkley River valley and adjacent areas to expand the collection of geochemical data in the region and possibly confirm the dominant direction of glacial transport inferred from the ice-flow indicators. A total of 135 till samples was collected for geochemical analyses (Figure 2). In addition, pebbles from the till, which were representative of the lithological composition, were collected for identification.

Field Methods

Till sampling sites were selected to set the greatest density of samples along transects perpendicular to established ice-flow direction as outlined in Levson (2002). Samples of basal till (the preferred sampling medium for till geochemistry programs in central BC; see Levson, 2001) were collected from natural and man-made exposures (roadcuts, river shore exposures, borrow pits and soil pits). The average sample depth was approximately 1 m and samples typically weighed between 3 and 5 kg. Field sites were marked with metal tags and flagging tape, both labelled with the unique site number. Locations of samples sites were plotted on a 1:50 000 scale NTS base map with the aid of aerial photographs and a hand-held GPS unit. Co-ordinates (NAD 83, Zone 9) obtained from the GPS unit for each sample site were recorded on field sheets.

Sedimentological data were collected at all sample sites. The data included descriptions of sediment type, primary and secondary structures, matrix texture, presence of fissility and compactness, total percentage and modal size of clasts, rounding of clasts, presence of striated clasts, and sediment genesis and thickness. Further information was noted on soil horizons, local slope, bedrock striae, bedrock lithology, clast provenance and abundance of mineralized erratics.

From each till sample, the lithology of 50 to 100 clasts in the 25 to 100 mm size range were identified and grouped into broad lithological categories to reflect major provenance areas. The objective of this analysis was to determine the direction and distance of glacial transport from source bedrock units.

Laboratory Methods

The till samples collected were air dried, split and sieved to the –230 mesh (<62.5 µm). One split from each sample was reserved for grain-size or other follow-up analyses. The –230 mesh fraction from each sample was analyzed by instrumental neutron activation analysis (INAA) for 35 elements at Activation Laboratories Ltd. (Ancaster, Ontario). Samples were also submitted to Acme Analytical Laboratories Ltd. (Vancouver, BC) for two types of analyses: inductively coupled plasma–emission spectrometry (ICP-ES) after aqua-regia digestion for 30 elements and flameless atomic absorption spectroscopy for Hg.

Quality Assurance–Quality Control

In order to discriminate geochemical trends related to geological factors from those that result from spurious sampling or analytical errors, a number of quality control measures were included in both the field and laboratory components of the project. These included the use of field duplicates, analytical or blind duplicates and control standards, one of each type being randomly inserted into each set of 17 routine field samples to make a block of 20 samples submitted for analysis. Field duplicates were taken from randomly selected field locations and subjected to identical laboratory preparation procedures. Analytical or blind duplicates consist of sample splits taken after laboratory preparation procedures but prior to analysis. Control reference standards include several BCGS geochemical reference materials comprising the –180 µm size fraction of a variety of bulk samples. Duplicate field and laboratory samples were included to measure sampling variability and analytical precision, respectively, whereas reference standards were used to measure the analytical accuracy.

Forthcoming Data Release

Till geochemical data and pebble lithology data from the Bulkley River valley and adjacent areas will be released as a Geoscience BC report by spring 2012. This report will include data from the geochemical survey and pebble sampling program, an analysis of the data in terms of exploration for metallic mineral deposits, and an evaluation of trends in the geochemical and lithological data with respect to the complex ice-flow history. The report will be accompanied by digital datasets containing the geochemical, clast lithology and sedimentological data collected at each field site.

Acknowledgments

Fieldwork and analytical analyses were funded by the BCGS as part of the Nechako NATMAP in central BC. Additional financial support was provided by Natural Sciences and Engineering Research Council of Canada (NSERC) through a doctoral research assistantship and an operational grant to the University of New Brunswick. The author thanks D. Heckmann, a student intern, for assistance with drafting the figures.

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