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Till geochemistry of the Finlayson Lake (105G), Glenlyon (105L) and east Carmacks (115I) map areas, YukonTerritory

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Abstract

This open file contains a compilation of the till geochemistry data for two regions of southern Yukon: 1) Finlayson Lake (105G) and, 2) Glenlyon (105L) and east Carmacks (115I) map areas. Till sampling was conducted during the 2001 and 2002 field seasons as part of the Yukon Targeted Geoscience Initiative (TGI), a joint program involving the Yukon Geological Survey and Geological Survey of Canada. Geochemical analyses have been conducted on the clay- (<0.002 mm) and silt- and clay- (<0.063 mm, -230 mesh) sized fractions by inductively coupled plasma mass spectrometry (ICP-MS) following an hydrochloric-nitric acids, and demineralized water digestion ($HCl:HNO_3:H_20$). Given the occurrence of emerald (a gem variety of beryl) at Regald Ridge in the Finlayson Lake map area, beryllium analyses were conducted on the silt- and clay-sized fraction by ICP-MS following a lithium metaborate ($LiBO_2$) fusion.

Introduction

The discovery of volcanogenic massive sulphide deposits in the middle 1990's (Schultze, 1996; Tucker et al., 1997) and an emerald occurrence in 1998 (Groat et al., 2002; Neufeld et al., 2003), both in the Yukon-Tanana Terrane (YTT) of southeastern Yukon, has demonstrated the potential of this terrane to host such mineralization (Hunt, 1997; 2002). Following the massive sulphide discoveries, bedrock mapping projects were implemented by the Yukon Geological Survey (formerly the Yukon Geology Program) in the Finlayson Lake map area (NTS 105G) to evaluate the stratigraphic setting of the mineralization and to establish the relationship between YTT and adjacent terranes (Murphy, 1997; 1998; Murphy and Piercey, 1999a; 1999b). Similarly, mapping commenced in the Glenlyon map area (NTS 105L) to the northwest (Colpron, 1999a; 1999b) because restitution of 450 km of dextral strike slip along Tintina Fault places the Glenlyon map area on structural trend to the south of the Finlayson Lake district (Colpron et al., 2003a).

To complement the regional bedrock investigations a till geochemical survey was initiated in 2000 in the northwest sector of the Finlayson Lake map area (Bond, 2001a, b), as a method to evaluate mineral potential of a poorly exposed sector of YTT, and supplement the regional stream geochemical database (Hornbrook and Friske, 1988; 1989).

Following these focused surveys led by the Yukon Geological Survey, bedrock mapping and a regional till sampling program were jointly implemented by the Yukon Geological Survey and the Geological Survey of Canada as part of the Yukon Targeted Geoscience Initiative (TGI). The purpose of this new project was to evaluate the mineral potential, to identify mineral exploration targets, and to stimulate mineral exploration within the YTT in southern Yukon. Field work was completed in the northern Finlayson Lake map area (NTS 105G) during the 2001 field season, and in the Glenlyon (NTS 105L) and eastern Carmacks (NTS 115I) map areas in 2002 (Fig. 1).

The purpose of this open file is to publicly release the results of the multi-element geochemical analyses on the clay-sized fraction, and the beryllium analyses on the silt- and clay-sized fraction of the till samples collected during the 2001 and 2002 field seasons (Appendix 1). The field notes describing the samples and the sample sites are also included in this open file (Appendix 1). To provide regional till data completeness and a better product for end-users, geochemical results of the silt- and clay-sized fraction of the samples collected in 2000 (Bond, 2001b), 2001 (Bond et al., 2002), and 2002 (Colpron et al., 2003b) are also included in this open file. Interpretation of the new till geochemistry data presented in this open file will be provided in an article to be published in Yukon Exploration and Geology 2003.

Bedrock geology and mineral potential

The YTT consists of polydeformed Devonian to Permian metasedimentary, metaigneous and metavolcanic rocks which were accreted to North America during Late Paleozoic time (Murphy et al., 2003). In the Finlayson Lake region, YTT is thrust over the North American miogeocline which consists of slightly metamorphosed, Silurian to Triassic sedimentary rocks (Murphy et al., 2002). The major volcanogenic massive sulphide deposits in the Finlayson Lake district are hosted in Late Devonian to Middle Mississippian (Fyre Lake, Kudz Ze Kayah, GP4F and Wolverine) and Early Permian (Ice) metavolcanic rocks of the YTT (Murphy et al., 2002) (Fig. 2). In the southern sector of the Finlayson Lake map area, at Regald Ridge, emerald crystals are found in association with quartz-tourmaline veins in mafic metavolcanic rocks near the contact zone of a mid-Cretaceous granite (Groat et al., 2002; Murphy et al., 2002; Neufeld et al., 2003). In addition, the Finlayson Lake district has potential for sedimentary-exhalative and epithermal mineralization (Murphy et al., 2002).

In the Glenlyon map area, the YTT is in fault contact to the northeast with rocks of the North American miogeocline and to the southwest with the Semenof block (mafic metavolcanic rocks). Known mineral occurrences within the Glenlyon map area include volcanic-hosted massive sulphide, fault-related epithermal gold, intrusion-related and sedimentary-exhalative mineralization (Colpron et al., 2003a).

Details on the bedrock geology component of the project are presented in Murphy et al. (2001), Bond et al. (2002) and Colpron et al. (2002; 2003b; 2003a).

Physiography and Quaternary geology

The Finlayson Lake map area is dominantly part of the Yukon Plateau which is a region of low relief with isolated plateaus. Within this map area, the Yukon Plateau is flanked to the south by the Tintina Trench and the Pelly Mountains, and to the east by the Selwyn Mountains. The Finlayson Lake map area was completely glaciated during the Late Wisconsinan McConnell Glaciation. During this glaciation, ice was generally flowing to the northwest from an ice-divide located over the Wolverine Lake region (Prest et al., 1967; Dyke, 1990; Jackson, 1994). To the southeast of Wolverine Lake, ice flow was generally to the southeast. Within the map area, ice flow was deflected around topographic obstacles (Fig. 2). For a more detail account of the ice-flow history and the Quaternary stratigraphy of the Finlayson Lake region the reader is referred to Jackson (1994) and Bond and Plouffe (2002).

The Glenlyon and eastern Carmacks map areas are dominantly part of the Yukon Plateau which is flanked by the Pelly Mountains to the east, and the Tintina Trench and MacMillan Highland to the northeast. The Cassiar and the Selwyn lobes of the Cordilleran Ice Sheet coalesced in the southwestern sector of the Glenlyon map area during the McConnell Glaciation (Ward and Jackson, 2000). Ice flow was generally to the northwest with source areas to the east and southeast in the Selwyn and Cassiar mountains (Fig. 3). At glacial maximum, glaciers were not thick enough to cover the highest summits and were not extensive enough to reach the western sector of the region. Therefore, ice-flow patterns were highly influenced by topography (Fig. 3). Ward and Jackson (2000), Jackson (2000), and Bond and Plouffe (2003) present a more detailed account of the ice-flow history and the Quaternary stratigraphy of the Glenlyon and eastern Carmacks map areas.

Field and laboratory methods

Prior to each field season, high mineral potential areas were defined based on existing bedrock geology and geophysical maps, known mineral occurrences, and regional stream sediment geochemistry. High mineral potential areas were also defined by the bedrock mappers during the field seasons. Till sampling was focused in high mineral potential areas located on plateaus overlain by a till veneer or a till blanket. Till sampling was not conducted in the larger valleys because thick accumulations of glaciofluvial sand and gravel and sporadic glacial lake sediments overlie till. The planning stage was greatly facilitated with the use of existing surficial geology maps (Jackson, 1994; 2000; Ward and Jackson, 2000) which illustrate the nature of the surficial sediments, the landforms and the ice limits. Foot traverses were planned at the base camps following air photo interpretation. Traverse lines were oriented perpendicular to ice-flow direction to provide the greatest cover of the concealed bedrock. Sample spacing along traverse lines averages 1 km. Detailed sampling (sample spacing: 50-250 m) was completed at the

Kudz Ze Kayah volcanogenic massive sulphide deposit in the Finlayson Lake map area (Fig. 2), and the Clear Lake sedimentary exhalative deposit (SEDEX) in the Glenlyon map area (Fig. 3).

All the sampling was conducted on foot traverses except along the Robert Campbell Highway and the access road to the Kudz Ze Kayah deposit. Samples were collected in hand-dug pits in unweathered till at a depth averaging 60 cm and consisted of 2.5 kg of bulk till and a separate bag of 50 pebbles. Sample sizes were limited because of backpack weight restrictions associated with foot traverses. As a result, large samples required for heavy mineral analysis could not be collected. Locally, permafrost and loess deposits were a hindrance to sampling. Site and sample descriptions were recorded and digitized in the field using a hand-held computer.

Pebble counts were completed in the field for a limited number of samples. However, the fine-grained nature of several bedrock units along with the difficulty of identifying lithological units in pebbles somewhat limited the use of till lithologies for glacial dispersal study. Pebble samples are stored in Whitehorse for future reference.

Geochemical analyses were conducted on two separate size fractions: silt and clay (-230 mesh or <0.063 mm) and clay (<0.002 mm). Bulk samples were dried at 40°C and then dry-sieved to separate the silt- and clay-sized fraction at Acme Analytical Laboratories Ltd. in Vancouver. The clay-sized fraction was separated at the Sedimentology Laboratory of the Geological Survey of Canada following procedures outlined in Lindsay and Shilts (1995). Phosphorus and sodium contamination likely occur during the clay separation because sodium metaphosphate is used as a defloculant during the process. Therefore, phosphor and sodium concentrations herein reported for the clay-sized fraction are doubtful. Geochemical analyses were conducted for 40 elements by inductively coupled plasma mass spectrometry (ICP-MS) after hydrochloric-nitric acids, and demineralized water digestion ($HCl:HNO_3:H_20$) (Table 1). Geochemical analyses were not conducted on the clay-sized fraction of the till samples collected in 2000. Analyses were done with 15 to 30 g of silt and clay, and 1 to 10 g of clay material.

Given the high potential for emerald (a gem variety of beryl), additional beryllium analyses, funded by the Yukon Geological Survey, were conducted on the silt- and clay-sized fraction of the till samples from the Finlayson Lake and Glenlyon map areas. Samples collected in 2000 in the Weasel Lake region were not analysed for beryllium. Beryllium analyses were conducted by ICP-MS following a lithium metaborate ($LiBO_2$) fusion. Fusion was selected for Be analyses because it is most effective in destroying silicates such as beryl.

Table 1. Upper (UDL) and lower (LDL) detection limits of the elements analysed by ICP-MS.

Element	unit	UDL	LDL	Element	unit	UDL	LDL
Ag	ppb	100	2	Na	%	10	0.001
Al	%	10	0.01	Ni	ppm	10 000	0.1
As	ppm	10 000	0.1	Os	ppb	500	1
Au	ppb	100	0.2	P	%	5	0.001
B	ppm	2000	1	Pb	ppm	10 000	0.01
Ba	ppm	10 000	0.5	Pd	ppb	1000	10
Be_1	ppm	1000	1	Pt	ppb	1000	2
Bi	ppm	2000	0.02	S	%	10	0.02
Ca	%	40	0.01	Sb	ppm	2000	0.02
Cd	ppm	2000	0.01	Sc	ppm	100	0.1
Co	ppm	2000	0.1	Se	ppm	100	0.1
Cr	ppm	10 000	0.5	Sr	ppm	10 000	0.5
Cu	ppm	10 000	0.01	Te	ppm	100	0.02
Fe	%	40	0.01	Th	ppm	2000	0.1
Ga	ppm	100	0.02	Ti	%	10	0.001
Hg	ppb	100	5	Tl	ppm	100	0.02
K	%	10	0.01	U	ppm	2000	0.1
La	ppm	10 000	0.5	V	ppm	10 000	2
Mg	%	30	0.01	W	ppm	100	0.2
Mn	ppm	10 000	1	Zn	ppm	10 000	0.1
Mo	ppm	2000	0.01				

Os analyses conducted on samples of the Glenlyon region only (2002 samples).
1 Be analyses conducted following a lithium metaborate fusion.

Quality control

Laboratory and field duplicates were randomly inserted in the sample suite to evaluate the combined analytical and sampling precision. At least one duplicate sample was added for every 10 samples. Results for the analytical precision testing are presented in Appendix 2 for the clay-sized fraction, and in Appendix 3 for the silt- and clay-sized fraction. In Appendices 2 and 3, the type of duplicate sample (field or laboratory) can be recognized from the sample number: laboratory duplicates contain the prefix “RE” or a sample number with the letter code “IG”, and field duplicates have the same sample number as the original sample, except for one digit. No notable difference was noted between the analytical and sampling precisions compiled separately.

Table 2 presents the combined analytical and sampling precision reported as the relative standard deviation (%) at the 95% confidence level for the surveys conducted in 2001 and 2002, and for both size fractions. Analytical precision was calculated following an approach modified from Garrett (1969). First, the total average was determined:

$$\overline{X} = \frac{\sum x_{1i} + \sum x_{2i}}{2N}$$

where X_{1i} is the sample analysis result

X_{2i} is the duplicate sample analysis result

N is the number of duplicate pairs.

Then the analytical variance was computed:

$$A^2 = \frac{1}{2N} \sum (X_{1i} - X_{2i})^2$$

where A^2 is the analytical variance

X_{1i} is the sample analysis result

X_{2i} is the duplicate sample analysis result

N is the number of duplicate pairs

Finally, the relative standard deviation was calculated with:

$$\text{RSD(95\% Confidence level)} = \frac{\text{A} \times 100\%}{\text{X}_{\text{av}}}$$

where Xav is the total average of all replicate results.

For most elements, the precision is better than ±20% and is considered adequate. The precision is worse for some elements for which the measured concentrations are near detection limit (e.g., beryllium, boron, palladium, platinum, sulphur and tungsten). For gold and tellurium, the precision is better for the clay-sized fraction than for the silt- and clay-sized fraction which is thought to reflect the heterogeneous distribution of the element in the coarser sample medium; in the case of gold, it is well known as the nugget effect. The cause of the poorer precision of boron analyses in the clay-sized fraction compared to the silt and clay-sized fraction is still unclear. For calcium, molybdenum, antimony, selenium and uranium the worse precision for the 2001 compared to the 2002 survey is attributed only to a few samples with poor reproducibility, which could be related to sample heterogeneity. Finally, in the case of titanium, analytical precision varies amongst surveys and size fractions which could be indicative of analytical inconsistency.

Table 2. Analytical precision expressed as the % relative standard deviation (RSD).

	2001-Finlayson		**2002-Glenlyon**	
Element	silt+clay	clay	silt+clay	clay
Ag	26	10	8	9
Al	6	6	7	6
As	9	9	9	7
Au	118	24	49	15
B	21	71	36	51
Ba	9	10	7	9
Be	90	--	97	--
Bi	8	10	7	5
Ca	27	10	4	4
Cd	11	9	9	8
Co	10	7	8	6
Cr	7	6	10	4
Cu	10	9	8	6
Fe	6	5	5	3
Ga	8	6	6	3
Hg	13	11	12	11
K	13	9	6	7
La	7	6	7	8
Mg	6	5	5	3
Mn	9	9	6	6
Mo	21	11	6	6

	2001-Finlayson		**2002-Glenlyon**	
Element	silt+clay	clay	silt+clay	clay
Na	14	14	11	13
Ni	9	6	9	5
Os	--	--	32	48
P	10	12	4	12
Pb	10	9	4	5
Pd	0	32	0	31
Pt	10	55	20	32
S	25	30	46	59
Sb	21	27	7	6
Sc	11	7	9	9
Se	28	34	16	11
Sr	16	8	5	8
Te	31	14	44	17
Th	10	6	5	6
Ti	30	18	6	22
Tl	8	10	4	5
U	21	11	8	4
V	7	7	7	5
W	15	15	17	25
Zn	8	6	6	4

The analytical accuracy was monitored with control standards. Six different standards were used: Till-1, Till-2 and Till-4 were obtained from the Canada Centre for Mineral and Energy Technology (CANMET), TCA-8010 is a GSC in-house standard and, DS3 and DS4 were provided by the analytical laboratory. Standard DS3 and DS4 were certified against the CANMET standards Till-4, LKSD-4 and STSD-1. At least one control standard was added for every 20 samples. Analytical results of the control standards are presented in Appendix 4.

Very few questionable results were obtained with the standard samples including elements for which the precision was found to be low and elements at concentrations near detection limits. Consequently, the analytical accuracy is judged satisfactory.

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