Geoscience BC Report 2023-07

Geochemical Reanalysis of Archived Till Samples

CICGR Project

Interior Plateau, Central BC

(Parts of NTS 093A, B, G, J, K, O)

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1.0 Introduction

Geoscience BC's Central Interior Copper-Gold Research (CICGR) project area is located in central British Columbia (BC) between the communities of Mackenzie and Williams Lake (Figure 1). This region has significant mineral potential; however, exploration is hindered by extensive unconsolidated Quaternary sediment units that obscure underlying bedrock. The CICGR project comprises a series of initiatives focused on producing publicly available geoscience data that supports exploration activities targeting mineral deposits that may be concealed by thick glacial sediments. This report provides the reanalysis results from archived till samples in and around the CICGR project area, which is one component of the surficial exploration initiative that also included 1:50 000-scale surficial geology mapping and new till geochemical and mineralogical surveys (Sacco et al., 2021; Sacco et al., 2022).

The reanalysis of archived samples using current laboratory techniques significantly improves the utility of the existing provincial till geochemical database by providing results that are directly compatible and comparable with current till data collected during the CICGR project and the previously completed TREK project (Jackaman and Sacco, 2014). Data sets compiled as part of this report are provided in Appendices A to D.

2.0 Previous Till Surveys

GSC Report 2023-07 supersedes GBC Report 2021-09 (Jackaman et al., 2021) originally published in March 2021. This updated report includes additional analytical results for two groups of archived till samples: 1) samples originally collected in the 1990s as part of regional till sampling programs led by the Geological Survey of Canada (GSC) in the Fort Fraser (NTS 93K) and Manson River (NTS 93N) map areas (Plouffe and Ballantyne, 1993; Plouffe, 1995; Plouffe and Williams, 1998; Plouffe and Williams, 2001; Plouffe et al., 2004); and 2) samples collected in the late 2000s in the McLeod Lake (NTS 93J) map area as part of Geoscience BC's QUEST project (Ward et al., 2013). Samples included in this report were collected from sites denoted by yellow symbols in Figure 1.

Regional till surveys conducted by the GSC in the 1990s involved the collection of 5 to 10 kg of subglacial till from road-cuts, river exposures and 1 m deep hand-excavated pits. Where exposures were greater than 2 m thick, multiple samples were collected in vertical profile at 0.5 to 2 m intervals. Sample site spacing averaged 5 km, although some site spacing was greater than 10 km. Silt-plus clay-sized fraction (<0.063 mm) and clay-sized fraction (<0.002 mm) were analyzed by inductively coupled plasma – atomic emission spectrometry (ICP-AES) after an aqua-regia digestion and by instrumental neutron activation analysis (INAA). A selection of the till samples was also processed for mineralogy and visible gold grain content. Analytical results from the original surveys and the detailed methodologies were published in 1995 by the GSC (Plouffe, 1995). For purpose of comparison, aqua regia digestion represents a partial to near-total acid digestion of the sample, whereas INAA is considered a total determination method.

Geoscience BC's QUEST regional till survey of parts of the McLeod Lake (NTS 93J) map area was conducted in 2008, 2009 and 2010. Approximately 3 kg of subglacial till was collected from exposures at an average sample spacing of 2 km. Clay-size fraction (< 0.002 mm) was analyzed by inductively coupled plasma mass spectrometry (ICP-MS) following an aqua-regia digestion and the silt-plus clay-sized fraction (<0.063 mm) was analyzed by INAA. Bulk till samples (>10 kg) were also collected from 138 sites for mineralogical analysis.

Figure 1. Location of the CICGR Project, the surficial mineral exploration study areas and the till sample locations.

These samples were disaggregated, followed by a separation of the >2 mm and <2 mm fractions. The <2 mm fraction was then pre-concentrated on a shaking table, with the finest, heaviest fraction being panned and examined under optical microscope to provide mineral grain counts and grain morphology for gold, cinnabar and other sulphides. After separation using a heavy liquid at 3.2 g/cm^3, the <0.25 mm-sized fraction was also analyzed by INAA. Analytical results from the original surveys and the detailed methodologies were published in 2013 by Geoscience BC (Ward et al., 2013).

Original geochemical analytical methods exclusive of mineralogical techniques, used for the two groups of till surveys are summarized in Table 1. There are some deficiencies in the suite of analytical methods reported relative to the most modern surveys of the area, both in the instrumentation used and compatibility between surveys. Briefly summarized, the 1990s GSC ICP-AES data lacks the low analytical detection limits achievable with modern ICP-MS instrumentation, while the QUEST silt-clay total determination INAA data lacks direct compatibility with widely used aqua regia till sample digestion methods. Furthermore, neither group of surveys reported major element oxide data at the time of initial release.

Table 1. Evolution of analytical methods used in the CICGR project area.

3.0 Archived Till Sample Recovery and Analysis

In collaboration with the GSC and the British Columbia Geological Survey (BCGS), attempts were made to recover an estimated 950 GSC till samples and 825 QUEST till samples from the GSC material storage facilities located in Ottawa. Sample pulps that were prepared by the lab during original sample processing are stored in plastic vials, retained in sequential order and secured in cardboard boxes. Character samples which are representative splits acquired from original, unprocessed samples are stored in 500-ml plastic containers.

From the stored GSC till samples, 902 representative 2-gram splits of the silt-plus clay-sized fraction (< 0.063 mm) were recovered. Only samples identified in accompanying field notes as subglacial till were recovered. The decommissioning of the existing storage facility disrupted our ability to gain safe access to all of the samples in 2019. Remaining samples were recovered in 2022 when the new materials storage facility was completed.

QUEST regional till survey samples were archived as original character samples and required processing by the lab to acquire silt-plus clay-sized fraction (< 0.063 mm) prior to analysis. Of the 825 samples, 798 samples were recovered, and 27 samples were determined to be missing from the collection.

The silt plus clay-sized fraction (<0.063 mm) of the recovered till samples plus appropriate quality control materials were analyzed by Bureau Veritas Commodities Laboratory (Vancouver, BC) for 53 elements by ICP-MS analysis (method code AQ250) of 0.5-gram samples following a modified aqua-regia digestion (1:1:1 HNO_3:HCl:H_2O); 22 elements by inductively coupled plasma–emission spectroscopy analysis (ICP-ES, method code LF302) of 0.2-gram samples following lithium metaborate/tetraborate fusion and a dilute nitric acid digestion; total C and total S determined by LECO combustion; and loss on ignition (LOI) at 1000 °C gravimetrically. Tables 2 and 3 list the elements determined and their reported detection limits.

Table 2. Elements determined by ICP-MS following a modified aqua-regia digestion (1:1:1 HNO_3:HCl:H_2O). Abbreviations: RDL, reported detection limit; ppm, parts per million; ppb, parts per billion; %, percent.

Element		RDL	Unit	Element		RDL	Unit	Element		RDL	Unit
Molybdenum	Mo	0.01	ppm	Calcium	Ca	0.01	%	Gallium	Ga	0.1	ppm
Copper	Cu	0.01	ppm	Phosphorus	P	0.001	%	Cesium	Cs	0.02	ppm
Lead	Pb	0.01	ppm	Lanthanum	La	0.5	ppm	Germanium	Ge	0.1	ppm
Zinc	Zn	0.1	ppm	Chromium	Cr	0.5	ppm	Hafnium	Hf	0.02	ppm
Silver	Ag	2	ppb	Magnesium	Mg	0.01	%	Niobium	Nb	0.02	ppm
Nickel	Ni	0.1	ppm	Barium	Ba	0.5	ppm	Rubidium	Rb	0.1	ppm
Cobalt	Co	0.1	ppm	Titanium	Ti	0.001	%	Tin	Sn	0.1	ppm
Manganese	Mn	1	ppm	Boron	B	20	ppm	Tantalum	Ta	0.05	ppm
Iron	Fe	0.01	%	Aluminum	Al	0.01	%	Zirconium	Zr	0.1	ppm
Arsenic	As	0.1	ppm	Sodium	Na	0.001	%	Yttrium	Y	0.01	ppm
Uranium	U	0.1	ppm	Potassium	K	0.01	%	Cerium	Ce	0.1	ppm
Gold	Au	0.2	ppb	Tungsten	W	0.1	ppm	Indium	In	0.02	ppm
Thorium	Th	0.1	ppm	Scandium	Sc	0.1	ppm	Rhenium	Re	1	ppb
Strontium	Sr	0.5	ppm	Thallium	Tl	0.02	ppm	Beryllium	Be	0.1	ppm
Cadmium	Cd	0.01	ppm	Sulphur	S	0.02	%	Lithium	Li	0.1	ppm
Antimony	Sb	0.02	ppm	Mercury	Hg	5	ppb	Palladium	Pd	10	ppb
Bismuth	Bi	0.02	ppm	Selenium	Se	0.1	ppm	Platinum	Pt	2	ppb
Vanadium	V	1	ppm	Tellurium	Te	0.02	ppm				

Table 3. Elements determined by ICP-ES following a lithium metaborate/tetraborate fusion and dilute nitric acid digestion, LOI, total C, and total S. Abbreviations: RDL, reported detection limit; ppm, parts per billion; %, percent.

Element		RDL	Unit	Element		RDL	Unit
Silicon dioxide	SiO_2	0.01	%	Cobalt	Co	20	ppm
Aluminium oxide	Al_2O_3	0.01	%	Copper	Cu	5	ppm
Iron(III) oxide	Fe_2O_3	0.04	%	Niobium	Nb	5	ppm
Magnesium oxide	MgO	0.01	%	Nickel	Ni	20	ppm
Calcium oxide	CaO	0.01	%	Scandium	Sc	1	ppm
Sodium oxide	Na_2O	0.01	%	Strontium	Sr	2	ppm
Potassium oxide	K_2O	0.01	%	Ytterium	Y	3	ppm
Titanium oxide	TiO_2	0.01	%	Zinc	Zn	5	ppm
Phosphorus pentoxide	P_2O_5	0.01	%	Zirconium	Zr	5	ppm
Manangese oxide	MnO	0.01	%	Loss on Ignition	LOI	0.1	%
Chromium(III) oxide	Cr_2O_3	0.002	%	Sum	Sum	0.01	%
Barium	Ba	5	ppm	Total C	C	0.02	%
Cerium	Ce	30	ppm	Total S	S	0.02	%

The addition of new modified aqua regia ICP-MS data for the silt-clay fraction provides new, lower analytical detection limits for a wider range of elements than previously available and ensures a greater degree of analytical compatibility between surveys. Furthermore, the addition of major element oxide data by a total fusion/ICP-ES method will permit new interpretations of geological provenance for these till samples, interpretations which were previously only available for adjoining surveys. Of note, the modified aqua regia ICP-MS re-analyses were carried out on 0.5-gram aliquots taken from 2-gram splits of archived material. This is not optimal for those elements such as Au or Pt which may be present, at trace levels, in particulate form and subject to considerable sub sampling variability. In the case of Au, for example, total determination by INAA on a much larger 30-gram subsample would be expected to yield more reliable results, even though the stated analytical detection limit is greater.

4.0 Quality Control

Quality control for analytical determinations was monitored using the commercial laboratory's in-house procedures in addition to analytical duplicate samples and reference standards that were prepared and inserted by the lab during sample processing. Field duplicate samples, if collected during original surveys were included in the analysis. Since original standard materials were not included as part of the archived sample collection they were not available. New standards inserted into the sample sequence included Canada Centre for Mineral and Energy Technology (CANMET) Certified Reference Materials TILL-1 and TILL-4; OREAS Till 21-046 and 047; and internal standards BC230, NVI, REDDOG, TREK-A and TREK-B which have been routinely used in previous BCGS and GBC programs. The use of laboratory analytical duplicates samples, field duplicate samples and standard reference material reflects the National Geochemical Reconnaissance Program quality control protocols described by Friske and Hornbrook (1991).

Although described as "till", the CANMET standards TILL-1 to Till-4 are, in fact, a combination of B and C soil horizon material (Lynch, 1996). The internal standards BC230, NVI and Red Dog are stream sediment collected at sites in British Columbia. TREK-A and TREK-B were created from bulk subglacial till sampled during the TREK program. While the standards do range from subglacial till to drainage sediment they represent material from a weathered surficial source and, as such, are reasonably comparable to the sample matrices. Moreover, repeated analysis of these standards has created sufficient data for confidently establishing quality control criteria. Different types of duplicate samples allow the measure of sampling and analytical variability. The laboratory duplicate samples (sieved and homogenized in the laboratory from the same field sample) determine the analytical variability; the field duplicate samples (collected in the field in two separate bags) determine the sampling and analytical variability.

A review of the quality control results determined that the reported analytical information is sufficient to assess the accuracy and precision of the data. This review included the calculation of the average coefficient of variation (CV_{AVR}; Figure 2) using the method proposed by Abzalov (2008).

$$CV_{AVR}(\%) = 100 \times \sqrt{\frac{2}{N}\sum_{i=1}^{N}\left(\frac{(a_i - b_i)^2}{(a_i + b_i)^2}\right)}$$

Figure 2. CV_{AVR} proposed by Abzalov (2008). The terms a and b represent the analyses of the first and second of the duplicate sample pair and N is the number of duplicate pairs.

This value provides an estimate of the overall sampling and analytical precision using the reported analyses for all duplicate samples. The average coefficient of variation and can range from 0%, when duplicate sample pairs have equal concentrations, to an upper value above 141.21% when duplicate results exhibit maximum differences. Table 4 lists the CV_{AVR} values for each element in the 35 field-duplicate silt-plus clay-sized (< 0.063 mm) fraction sample pairs analyzed by modified aqua regia/ICP-MS. For the purposes of this report, values below 15% indicate good data quality, values between 15 and 30% acceptable quality and between 30% and 50% marginal quality (see Heberlein et al., 2017).

Table 4. CV_{AVR} values calculated following Abzalov's (2008) method for each element in the 35 field-duplicate sample pairs analyzed by modified aqua regia/ICP-MS. Green indicates good precision, yellow acceptable precision and red, marginal precision.

Element	Unit	Method	CV_{AVR} (%)	Element	Unit	Method	CV_{AVR} (%)	Element	Unit	Method	CV_{AVR} (%)
B	ppm	ICP-MS	0.00	**Rb**	ppm	ICP-MS	4.02	**Zr**	ppm	ICP-MS	9.1
S	%	ICP-MS	0.00	**Ga**	ppm	ICP-MS	4.26	**Ag**	ppb	ICP-MS	9.6
Ta	ppm	ICP-MS	0.00	**Y**	ppm	ICP-MS	4.34	**Ge**	ppm	ICP-MS	11.3
Ti	%	ICP-MS	1.92	**Cu**	ppm	ICP-MS	4.41	**Cd**	ppm	ICP-MS	11.5
V	ppm	ICP-MS	2.09	**Al**	%	ICP-MS	4.46	**Be**	ppm	ICP-MS	12.7
P	%	ICP-MS	2.24	**Co**	ppm	ICP-MS	4.67	**Hf**	ppm	ICP-MS	12.7
Ce	ppm	ICP-MS	2.69	**AS**	ppm	ICP-MS	4.73	**Re**	ppm	ICP-MS	14.6
U	ppm	ICP-MS	2.85	**Tl**	ppm	ICP-MS	4.76				
La	ppm	ICP-MS	2.96	**Mo**	ppm	ICP-MS	4.76	**Hg**	ppb	ICP-MS	15.45
Mg	%	ICP-MS	3.11	**Pb**	ppm	ICP-MS	4.79	**Ca**	%	ICP-MS	16.20
Pd	ppb	ICP-MS	3.12	**Cs**	ppm	ICP-MS	4.88	**In**	ppm	ICP-MS	18.71
Fe	%	ICP-MS	3.15	**K**	%	ICP-MS	4.95	**Te**	ppm	ICP-MS	19.53
Na	%	ICP-MS	3.26	**Bi**	ppm	ICP-MS	4.96	**W**	ppm	ICP-MS	20.63
Zn	ppm	ICP-MS	3.40	**Sc**	ppm	ICP-MS	5.04	**Nb**	ppm	ICP-MS	21.90
Cr	ppm	ICP-MS	3.64	**Sb**	ppm	ICP-MS	5.19	**Sn**	ppm	ICP-MS	31.27
Ni	ppm	ICP-MS	3.85	**Mn**	ppm	ICP-MS	5.36	**Pt**	ppb	ICP-MS	31.39
Th	ppm	ICP-MS	3.90	**Li**	ppm	ICP-MS	6.13	**Se**	ppm	ICP-MS	37.96
Ba	ppm	ICP-MS	3.98	**Sr**	ppm	ICP-MS	8.63	**Au**	ppm	ICP-MS	38.14

The calculation of the relative standard deviation (RSD) of the ICP-MS analytical results of the reference standards provides an estimate of precision. Generally, those values below 15% RSD indicate good precision, values between 15 and 30% acceptable precision and between 30 and 50% marginal precision. Reported detection limit (MDL), mean and percent RSD values for reference standards are presented in Table 5. Percent RSD values > 15% (30% precision at the +/- 95% confidence limit) are highlighted.

Table 5. Reported detection limit (RDL), mean and percent RSD (standard deviation/mean) values for CANMET TILL-1 (n=2), CANMET TILL-4 (n=4), BC230 (n=6), 4 NVI (n=4), REDDOG (n=9), TREK-A (n=5), TREK-B (n=4), OREAS 46 (n=10) and OREAS 47 (n=22) samples by modified aqua regia–ICP-MS.

			TILL1		TILL4		BC230		NVI		REDDOG		TREK A		TREK B		OREAS 46		OREAS 47	
Element	**MDL**	**Unit**	**Mean**	**%RSD**	**Mean**	**%RSD**	**Mean**	**%RSD**	**Mean**	**%RSD**	**Mean**	**%RSD**	**Mean**	**%RSD**	**Mean**	**%RSD**	**Mean**	**%RSD**	**Mean**	**%RSD**
Ag	2	ppb	220.50	4.17	177.17	5.80	96.00	5.39	109.75	20.92	84.67	8.27	95.00	8.74	94.50	5.57	21.90	14.98	107.77	5.27
Al	0.01	pct	1.81	1.18	1.90	3.08	2.84	5.27	2.92	3.64	2.07	3.72	2.13	3.47	2.09	5.00	0.73	5.98	0.78	5.99
As	0.1	ppm	15.55	3.18	105.05	3.91	14.12	15.02	14.15	6.12	5.84	6.69	7.10	8.45	6.95	4.47	0.61	27.27	9.61	5.24
Au	0.2	ppb	13.30	57.42	4.67	17.55	5.20	53.45	49.40	174.18	38.99	66.26	13.64	112.84	5.90	14.11	0.66	79.60	37.32	6.68
B	20	ppm	10.00	0.00	10.00	0.00	10.00	0.00	10.00	0.00	10.00	0.00	10.00	0.00	10.00	0.00	20.00	0.00	20.00	0.00
Ba	0.5	ppm	77.40	0.00	65.98	2.56	62.03	4.81	65.05	2.56	54.60	7.61	51.08	7.75	51.68	5.05	50.90	9.88	58.61	8.34
Be	0.1	ppm	0.50	0.00	0.95	8.81	0.37	14.08	0.40	20.41	0.20	0.00	0.46	19.44	0.45	12.83	0.19	16.64	0.20	15.43
Bi	0.02	ppm	2.01	2.11	46.30	6.02	0.14	17.47	0.23	39.17	0.53	8.95	0.23	16.73	0.22	8.06	0.02	30.30	0.14	9.73
Ca	0.01	pct	0.33	4.29	0.12	7.00	1.35	7.44	1.40	6.20	0.75	6.31	0.24	4.17	0.24	4.03	0.61	8.61	0.55	8.51
Cd	0.01	ppm	0.20	10.88	0.15	14.08	0.30	9.43	0.30	8.16	0.23	16.25	0.10	20.91	0.09	10.35	0.03	19.57	0.51	9.32
Ce	0.1	ppm	53.65	1.19	53.22	4.88	15.15	6.42	15.45	1.71	9.59	7.47	64.54	12.01	62.10	7.74	26.07	9.90	42.53	6.38
Co	0.1	ppm	13.35	4.77	6.05	8.28	24.15	5.60	24.05	2.26	11.17	6.46	15.06	5.26	14.93	3.96	5.63	7.86	50.25	4.07
Cr	0.5	ppm	29.50	5.27	24.08	6.38	51.88	3.69	52.38	3.16	21.18	7.45	50.62	5.82	47.93	5.36	24.83	8.88	30.75	6.26
Cs	0.02	ppm	0.65	1.10	7.91	3.04	0.56	2.99	0.57	2.98	0.35	5.25	1.05	7.59	1.01	3.75	0.34	7.75	1.13	6.51
Cu	0.01	ppm	49.05	3.13	246.84	6.07	100.93	4.42	105.27	3.55	170.70	4.80	73.94	5.43	69.32	3.32	22.63	4.60	157.08	3.51
Fe	0.01	pct	3.30	1.29	3.33	2.66	4.68	3.83	4.79	1.81	4.37	2.60	3.87	0.84	3.79	4.25	1.40	5.71	1.58	4.79
Ga	0.1	ppm	5.95	3.57	5.83	5.16	7.90	8.05	8.03	4.12	5.89	5.13	5.52	9.45	5.73	2.20	2.48	11.69	2.60	10.36
Ge	0.1	ppm	0.05	0.00	0.05	0.00	0.05	0.00	0.05	0.00	0.06	30.00	0.05	0.00	0.05	0.00	0.10	0.00	0.10	0.00
Hf	0.02	ppm	0.03	0.00	0.11	9.99	0.14	15.36	0.11	26.54	0.15	9.03	0.01	323.55	1.00	49.84	0.15	14.48	0.17	7.85
Hg	5	ppb	85.50	10.75	11.17	113.33	159.33	81.47	93.75	16.46	25.22	18.99	48.80	9.98	65.00	21.97	7.80	24.02	14.77	21.70
In	0.02	ppm	0.05	28.28	0.32	3.95	0.04	23.90	0.04	28.57	0.07	13.62	0.00	0.00	-0.02	0.00	0.02	0.00	0.04	15.98
K	0.01	pct	0.06	12.86	0.30	3.56	0.06	9.96	0.06	10.50	0.04	8.11	0.11	3.99	0.11	4.44	0.11	8.51	0.11	5.79
La	0.5	ppm	18.55	5.72	28.17	7.34	6.35	6.36	6.70	5.02	4.84	9.06	27.98	12.90	27.73	11.92	15.29	13.08	25.25	8.87
Li	0.1	ppm	10.15	3.48	20.12	5.80	7.63	8.87	7.85	4.82	4.43	6.77	33.36	12.21	30.90	5.67	6.55	6.84	8.43	7.41
Mg	0.01	pct	0.57	1.25	0.51	3.61	1.14	4.97	1.17	2.55	0.72	3.14	0.89	2.01	0.88	4.47	0.44	7.14	0.47	6.22
Mn	1	ppm	1127.00	0.63	261.67	4.64	1012.83	4.74	1044.00	2.72	420.89	7.27	342.40	6.57	341.75	4.58	249.90	4.48	272.09	4.46
Mo	0.01	ppm	0.67	3.19	14.70	6.31	1.50	9.71	1.47	2.96	13.87	15.18	0.79	7.65	0.78	4.86	0.63	7.02	12.33	4.83
Na	0.001	pct	0.03	2.18	0.03	9.13	0.03	7.94	0.04	7.96	0.02	11.38	0.01	22.61	0.01	12.35	0.07	7.34	0.08	7.30
Nb	0.02	ppm	1.04	4.78	1.80	4.51	0.94	14.08	0.83	20.47	0.28	20.95	0.36	9.63	0.31	1.89	0.16	20.81	0.31	24.27
Ni	0.1	ppm	19.35	3.29	14.08	7.25	43.33	5.00	42.15	4.44	13.20	6.48	39.88	10.91	39.25	1.91	16.20	8.07	80.30	3.53
P	0.001	pct	0.09	1.64	0.07	8.08	0.07	6.98	0.08	6.17	0.05	5.32	0.07	18.97	0.06	3.95	0.05	5.03	0.05	6.41
Pb	0.01	ppm	14.32	3.11	37.11	4.68	5.45	8.09	5.60	4.40	7.18	5.58	10.36	7.21	9.92	6.74	1.93	11.78	271.35	5.03
Pd	10	ppb	5.00	0.00	5.00	0.00	6.17	46.34	6.50	46.15	5.00	0.00	5.00	0.00	5.00	0.00	10.00	0.00	43.41	7.27
Pt	2	ppb	1.00	0.00	1.00	0.00	1.17	34.99	2.00	0.00	1.33	75.00	1.20	37.27	1.00	0.00	2.00	0.00	26.36	14.36
Rb	0.1	ppm	6.30	4.49	36.32	5.41	3.07	6.74	3.08	3.11	1.73	7.63	12.50	9.60	11.85	5.27	6.13	7.34	7.16	5.75
Re	1	ppb	0.50	0.00	0.75	81.65	1.17	58.55	1.13	55.92	15.78	62.89	0.50	0.00	0.50	0.00	1.00	0.00	1.00	0.00
S	0.02	pct	0.02	47.14	0.07	8.43	0.17	3.32	0.17	3.50	0.60	5.14	0.01	0.00	0.01	0.00	0.02	0.00	0.04	11.04
Sb	0.02	ppm	3.98	3.02	0.47	4.25	0.20	7.07	0.26	22.21	0.14	18.85	0.25	11.34	0.23	9.54	0.06	9.58	0.18	7.93
Sc	0.1	ppm	4.80	5.89	4.48	4.77	7.82	4.82	8.05	6.29	5.73	5.23	4.52	9.18	4.48	6.15	2.46	14.74	2.88	10.56
Se	0.1	ppm	0.30	94.28	0.48	20.34	1.20	14.91	1.15	15.06	3.03	4.66	0.29	60.22	0.30	27.22	0.10	0.00	0.14	53.29
Sn	0.1	ppm	0.90	15.71	5.12	5.72	0.42	18.07	0.50	16.33	0.62	13.39	0.12	108.65	0.20	0.00	0.38	20.76	2.09	8.97
Sr	0.5	ppm	10.00	5.66	9.10	6.85	57.35	8.60	58.55	2.49	52.21	6.57	25.76	13.86	24.38	4.51	27.44	12.81	31.55	10.11
Ta	0.05	ppm	0.03	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.05	0.00	0.05	0.00
Te	0.02	ppm	0.03	47.14	0.19	5.77	0.07	10.50	0.08	26.60	0.49	6.25	0.06	8.56	0.06	13.61	0.02	0.00	0.02	0.00
Th	0.1	ppm	2.95	2.40	12.32	7.68	1.17	16.85	1.08	4.65	1.22	10.65	8.68	13.83	8.25	12.10	2.83	15.00	3.14	12.11
Ti	0.001	pct	0.08	9.20	0.11	6.11	0.25	6.85	0.27	5.45	0.14	7.80	0.07	10.46	0.07	7.87	0.07	13.65	0.07	8.66
Tl	0.02	ppm	0.14	5.24	0.40	3.44	0.06	9.11	0.06	10.50	0.03	19.32	0.13	10.65	0.12	4.26	0.06	13.18	0.08	8.21
U	0.1	ppm	0.90	0.00	2.62	7.01	0.90	7.03	0.93	5.41	0.46	11.57	0.76	11.77	0.78	12.35	0.42	10.04	0.42	9.44
V	1	ppm	56.00	5.05	39.33	5.25	138.00	6.33	141.25	5.96	97.33	3.81	52.60	2.55	52.75	5.22	21.60	9.81	23.73	6.53
W	0.1	ppm	0.08	47.14	100.00	0.00	0.16	111.95	0.06	40.00	0.05	0.00	0.06	37.27	0.05	0.00	0.10	0.00	0.10	0.00
Y	0.01	ppm	12.64	1.57	8.32	7.16	10.35	6.90	10.63	4.16	6.12	7.85	6.02	10.58	5.91	6.48	4.98	9.63	5.43	7.98
Zn	0.1	ppm	68.65	2.78	57.00	5.97	77.30	4.81	75.90	1.07	52.74	5.75	76.38	9.70	75.83	4.04	20.17	7.34	212.18	4.19
Zr	0.1	ppm	0.90	0.00	4.42	6.31	5.67	16.20	5.50	12.15	5.59	6.42	1.18	13.93	1.00	14.14	4.86	5.42	5.98	6.34

Table 6 compares mean and standard deviation (SD) values for Au, Co, Cu, Ni, Pb and Zn by modified aqua regia ICP-MS reported in Table 4 and by dilute HNO3-HCl - AAS reported by Lynch, 1995 in CANMET standards TILL-1 and TILL-4. Mean values by modified aqua regia ICP-MS for all of the elements are identical or within 5% of those reported by Lynch indicating that the analyses are accurate. With the exception of Au, the standard deviation values for Co, Cu, Ni, Pb and Zn are small indicating that the analyses are also precise over the concentration range of the standards.

Table 6. Comparison of CANMET TILL-1 and TiLL-4 mean and standard deviation (SD) values for Au by total determination and selected elements by modified aqua regia ICP-MS and by dilute HNO3-HCl - AAS reported by Lynch, 1995.

		TILL-1				TILL-4			
		Mean	SD	CANMET Mean	CANMET SD	Mean	SD	CANMET Mean	CANMET SD
Au	ppb	13.3	7.8	13	4	4.7	0.8	5	3
Co	ppm	13.5	0.6	12	1	6.1	0.5	6	2
Cu	ppm	49.1	1.5	49	2	246.8	14.9	252	7
Ni	ppm	19.4	0.6	17	2	14.1	1.0	14	2
Pb	ppm	14.3	0.4	14	3	37.1	1.7	37	5
Zn	ppm	68.7	1.2	71	5	57.0	3.4	62	4

5.0 Genetic Interpretation of Archive Till Samples

Subglacial till is deposited by lodgement and melt-out processes at the base of a glacier. It is the primary target for till geochemical surveys because it is a first derivative of bedrock (Shilts, 1993), its source area can be determined by reconstructing ice-flow histories, and it produces a geochemical signature that is areally more extensive than its bedrock source (Levson, 2001). Other types of till and other glacial diamicts consist of material with various sources, and more complex transport histories and depositional processes making the bedrock source area difficult or impossible to determine. Geochemical results from these materials can indicate changes in regional bedrock composition, but are less useful in determining zones of potential mineralization. Sediments with different geneses must be evaluated independently to reduce variability in the data set and improve anomaly recognition (Sacco et al., 2021).

The CICGR reanalysis dataset was compiled from surveys that specifically targeted subglacial till and that were conducted by trained field crews. As such, all samples are assumed to be subglacial till unless otherwise indicated in the original sample notes. The sample notes have been included as part of the digital data files so users can identify non-subglacial till samples within the dataset.

6.0 Digital Data Presentation

Information presented in this report includes new analytical results determined from till samples recovered from archived storage in 2019 and 2022. Original field and analytical information published as part of the previously conducted till surveys have been included. Results from the reanalysis of the till samples are being released as reported by the commercial laboratory. The accompanying digital data files are provided in Microsoft® Excel (XLSX) tables and are described as follows:

***Appendix A**: GBC Report 2023-07 Digital Data File 1*

Includes new analytical results for archived till samples collected during regional till surveys conducted by the GSC in the 1990s.

***Appendix B**: GBC Report 2023-07 Digital Data File 2*

Includes new analytical results for archived till samples collected during regional till surveys completed as part of Geoscience BC's QUEST Project.

The Microsoft® Excel (XLSX) data files are each subdivided into tabs which are described as follows:

1. *TAB: DATA FILE NOTES*
   Explanation of abbreviations, column heading codes and method detection limits.

2. *TAB: ORIGINAL FIELD DATA*
   Field data presented as originally published or acquired from original digital data files or transcribed from hard-copy notes.

3. *TAB: NEW ICPMS*
   New determinations for 53 elements by ICP-MS analysis of 0.5-gram samples following a modified aqua-regia digestion (1:1:1 HNO_3:HCl:H_2O).

4. *TAB: NEW MAJOR OXIDES*
   New determinations for 22 elements by ICP-ES analysis of 0.2-gram samples following lithium metaborate/tetraborate fusion and a dilute nitric acid digestion, total C and total S determined by LECO combustion and loss on ignition (LOI) at 1000 °C gravimetrically.

5. *TAB: ORIGINAL ICP*
   Previously published minor and trace elements in silt-plus clay and/or clay-sized fractions by ICP-AES or ICP-MS.

6. *TAB: ORIGINAL INAA*
   Previously published minor and trace elements in silt-plus clay and/or clay-sized fractions by INAA.

7. *TAB: ORIGINAL MINERALOGY*
   Previously published mineralogy data and other associated analytical data.

8. TAB: ORIGINAL GOLD GRAIN COUNTS AND DESCRIPTIONS (*GBC Report 2023-07 Digital Data File 1)*
   Previously published gold grain data.

Appendix C: GBC Report 2023-07 Lab Certificates (PDF file)

Appendix D: GBC Report 2023-07 QC Data (XLXS file)

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