



Compiled till geochemical data for British Columbia

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Front cover: Subglacial till sample site on Horsefly River, 2 km north of Ratdam Lake, Horsefly map area (NTS 093A/06). **Photo by Travis Ferbey.**

Back cover: Subglacial till sample site 7 km northwest of past-producing Equity Silver Cu-Ag-Au mine, Colleymount map area (NTS 093L/01). **Photo by Travis Ferbey.**



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Abstract

The complete data set of publically available, regional-scale, till geochemical surveys carried out in British Columbia by the British Columbia Geological Survey, the Geological Survey of Canada, and Geoscience BC compiles 39 reports released between 1992 and 2017, and includes geochemical data for 10,454 samples. Five Microsoft Excel tables generated from this database provide analytical determinations for the clay (<2 µm) and silt plus clay (<63 µm) size fractions of tills by inductively coupled plasma mass spectrometry after an aqua regia or modified aqua regia digestion, after a lithium metaborate fusion, and by instrumental neutron activation. These data tables can be brought into GIS software and integrated with other geoscience data to generate new exploration targets and design follow-up exploration programs.

Keywords: Till geochemistry, database, mineral exploration, till, regional geochemistry

1. Introduction

Till geochemical surveys are important tools for mineral exploration. The wealth of information generated by such surveys in British Columbia is spread across many individual reports published by the British Columbia Geological Survey (BCGS), Geological Survey of Canada (GSC), and Geoscience BC (GBC) over a 25 year period, making it difficult for explorationists to access and use. The data tables presented in this report build on the first compilation of till geochemical data for British Columbia (Lett, 2008) and include in one place all geochemical determinations on the clay (<2 µm) and silt plus clay (<63 µm) size fractions for publically available regional-scale till geochemical surveys.

These data tables were produced by querying a relational database designed to capture spatial and geochemical data for all till samples collected in British Columbia. This database is managed internally by the BCGS and, with minimum redundancy, can effectively address relationships between sample, publication, analyte, analytical method, and laboratory in cases where: 1) samples were analyzed using different methods at different laboratories; 2) samples were re-analyzed; 3) samples were re-analyzed with different minimum detection limits; and 4) samples were published in multiple publications. The relational database is not publically available but data tables derived from it are. The five till geochemistry data tables presented here are organized by size fraction and analytical method.

2. Till geochemistry database

2.1. Database development

Managing data in an organization-wide database, like a relational database, is more efficient and effective than a file-based approach. It enables long-term data preservation, mitigates data loss, provides an effective means to systematically and consistently integrate data collected for different projects and from different project areas, and can link directly into existing organizational web GIS systems such as MapPlace (the BCGS platform for data discovery, visualization, extraction, and distribution).

Database development commonly follows iterative stages including requirement analysis, logical design, implementation, and database population (Connolly and Begg, 1999). We followed these stages closely to develop the BCGS till geochemical database, as was done with recent compilations of Regional Geochemical Survey (RGS) stream-sediment data (Rukhlov and Naziri, 2015) and litho-geochemical data (Han et al., 2016). Our relational data model (Fig. 1) consists of three data entities (DATA_PUBLISH, DATA_SAMPLE, and DATA_ANALYTE) and three meta-data entities (CODE_METHOD, CODE_LAB, and CODE_UNIT). The three data entities are used to model and store the data suggested by their names (e.g., DATA_SAMPLE for till sample data) including information such as analytical method and laboratory for every analyte determination. Keeping data and meta-data together is

important. For example, an interpretation of Au values could change depending if the digestion used was partial or total.

This model aligns with the Open Geoscience data model (Granitto et al, 2012; Watson and Evans, 2012). We constructed the till geochemical database using Microsoft Access; peripheral applications were developed as three Python scripts to assist routine data management activities, including data quality control, data loading, and data table generation.

2.2. Database management

The development and operation of this database makes it possible for the BCGS to centrally manage till geochemical data through time, which leads to improved data consistency, timely data update, routine delivery of customized data product, and data loss mitigation. The operation and dataflow of the database follows five steps (Fig. 2): 1) data compilation; 2) data screening for initial QA/QC; 3) data loading; 4) product generating; and 5) Product QA/QC. If errors are found in step 5, steps 1 to 4 are repeated. Although the data tables derived from the database are publically available, the database, which resides in the BCGS, is not.

During data compilation (step 1), data are retrieved from different sources and saved to XLS files in a standardized format. Commonly, a single source fails to provide all the data

and meta-data required by the database, or multiple sources give inconsistent results. Data completion, verification, and correction are commonly needed to deal with these situations. Data QA/QC is then conducted (step 2) by the corresponding Python script (**screening.py**), which was designed to flag the most common data errors in the source or introduced in the data compilation step. These include errors such as unrealistic determinations and units, improper methods, incorrect sample locations, and redundant samples. The flagged errors are then corrected manually. Following QA/QC, data are loaded into the database (step 3). This is an automatic step done by the corresponding Python script (**loading.py**). To avoid generating duplicate entries, the script checks if a sample is already in the database. Product generating also conducted by a Python script (**generating.py**), extracts data and outputs them in formats suited to the user (e.g., Comma-Separated-Value (CSV) files, ESRI shapefiles, or MS Access files). The data tables presented here are produced at this step.

QA/QC (step 5) includes plotting samples using coordinates provided in data tables to verify locations. Each sample location is examined manually for errors including systematic offsets between samples that were re-analyzed, significant offset from areas where samples were likely collected (i.e., along roads), and samples that fall within a waterbody (e.g.,

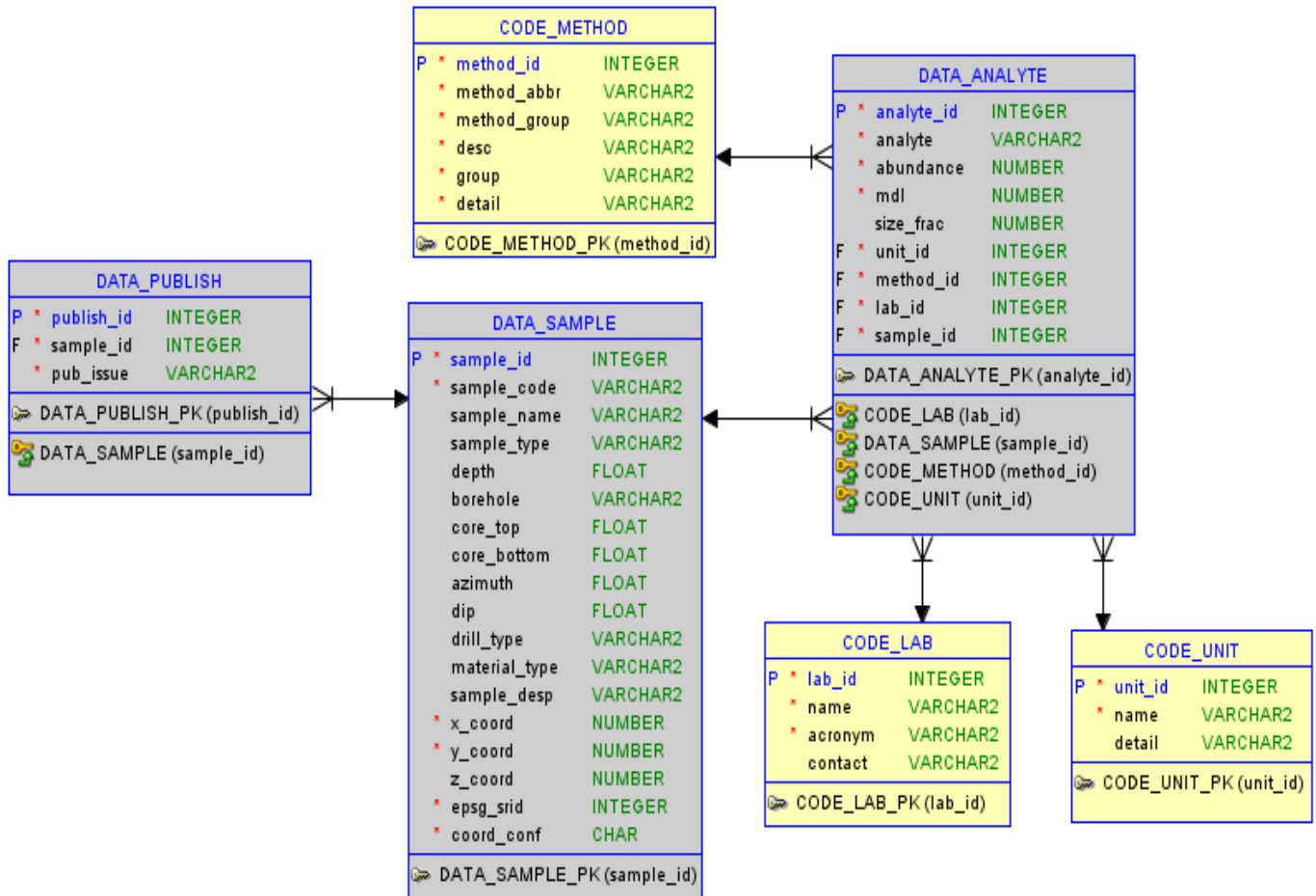


Fig. 1. Relational data model for British Columbia Geological Survey till geochemical database.

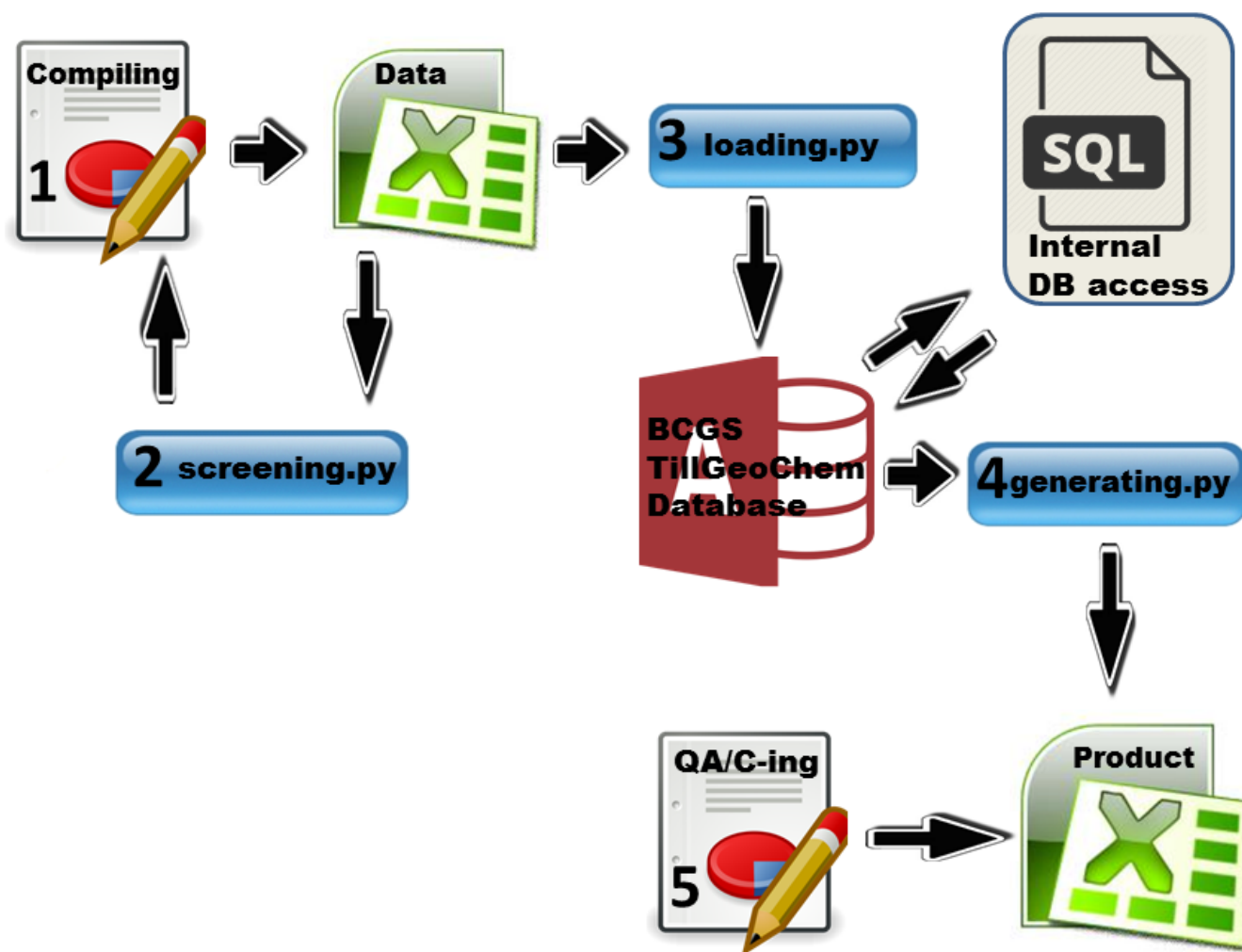


Fig. 2. Data flow in British Columbia Geological Survey till geochemical data management. Steps discussed in text are labeled 1 through 5.

lake). When mislocated samples are identified, the original report is re-examined to verify sample location and coordinate system information (e.g., NAD 27 or NAD 83). Following the generation of the data product (step 4), five samples from each source publication are checked against the original data release or lab files step 5 to ensure that systematic errors were not introduced during compilation (step 1), loading (step 3), or data product generation (step 4).

3. Till geochemistry data

The data tables presented here are derived from the till geochemistry database. They build on the original till geochemistry compilation by Lett (2008) and are complemented by a recent compilation of ice-flow indicators in British Columbia and Yukon (Arnold et al., 2016). The regional-scale till geochemical surveys in British Columbia included here were carried out by BCGS, GSC, and GBC. The resultant data are presented in five Excel data tables, organized by size fraction and analytical method (Table 1). Column heading definitions are provided in Table 2.

Each sample in these data tables includes a reference to an original report. These reports and previous compilations are

included in the “Pub_Issue” columns (up to “Pub_Issue3”). Users are directed to the reports for detailed information because analytical methods can vary greatly between different surveys. In some cases, original reports may contain additional data that are not presented in this release including: sedimentological data, indicator mineral data, clast lithological data, or data related to the analysis of sample media other than tills (e.g., colluvium or glaciofluvial sediments). This iteration of the till geochemical database does not contain data related to property-scale surveys carried out in British Columbia, or subsurface samples collected using a drill. Users are directed to Bustard and Ferbey (2016) for a complete listing of these studies.

3.1. Sample media

The material sampled is identified in the “Material_Type” column of the data tables. In some cases, authors of re-analysis reports have re-interpreted the genetic classification of samples. In all cases, the classification used in the “Material_Type” column is that used by authors of the original report.

Till geochemical surveys target subglacial tills, commonly considered a first derivative of bedrock (Shilts, 1993). They

Table 1. Methods and size fractions for the five data tables in this release.

Method	Size Fraction	
	<2 μm	<63 μm
ICP – Aqua regia	Data Table 1 - ICP AR clay fraction.xlsx	Data Table 2 - ICP AR silt plus clay fraction.xlsx
ICP – Lithium metaborate fusion	Data Table 3 - ICP Fusion clay fraction.xlsx	Data Table 3 - ICP Fusion clay fraction.xlsx
INAA		Data Table 5 - INA silt plus clay fraction.xlsx

have a relatively straightforward transport history that coincides with an area's ice-flow history, and thus can be used to characterize and locate buried mineralization (Levson, 2001). Historically, for till geochemical surveys conducted in British Columbia, other sediment types have been collected including including other till facies (ablation till, colluviated till) and glaciogenic sediments (glaciomarine, glaciofluvial), and colluvium. These deposits commonly have more complicated transport histories and identifying the source of geochemical anomalies may be difficult. To ensure a consistent data set, only subglacial till and colluviated till samples are included in the data tables presented here.

3.2. Sample sites and locations

Consistent information is provided for all sample sites in the data tables. The spatial distribution of samples, by size-fraction

and analytical method, is presented in Figure 3. Confidence in sample locations is generally high because most regional-scale till geochemical surveys were conducted along roads (where positions could be readily established) and, as the technology became available, recorded Global Positioning System (GPS) coordinates for sample sites. However, in some earlier studies sample site coordinates have been rounded to the nearest 50 to 100 m. This is obvious in the original reports, with sample coordinates in their original coordinate system (e.g., UTM, NAD 27), but may not be obvious in the data tables presented here as sample location information has been converted to a common coordinate systems (i.e., UTM, NAD 83). These samples with less precise location information are assigned an “L” in the “Coord_Conf” field. “M”, for medium, is used as the default value in the “Coord_Conf” field, and “H” is used in cases where there is evidence in the report or when plotting

Table 2. Description of attributes in the five data tables in this release.

Attribute Name	Description	Example
Sample_ID	Sequential number used as the row counter (generated by database)	16
Sample_Code	Standardized sample name derived from sample name in reports	95-1018
Sample_Name	Original sample name in the source report	BCGS951018
Pub_Issue Pub_Issue1 Pub_Issue2 Pub_Issue3	Reports that have included analysis of the sample in question	OF1997-09
Sample_Type	Type of sample (surficial or drill)	Surficial
Depth	Depth of sample collection below modern day surface in metres	1.2
Duplicate	10 or 20 to indicate whether sample was a field duplicate or not	10
Material_Type	Type of till or sediment sampled	Subglacial Till
NAD83_Long	NAD83 longitude in decimal degrees	-119.6581849
NAD83_Lat	NAD83 Latitude in decimal degrees	51.33397404
Elev	Sample elevation in metres	1246
Coord_Conf	Confidence in the sample location, L = Low; M = Medium; H = High	H
NTS_Map	NTS 1:50 000 map sheet	093N01
UTM_Easting	NAD83 UTM Easting	434652
UTM_Northing	NAD83 UTM Northing	6110959
Hg_AAS_ppb	Hg concentration in ppm determined by Cold Vapour Atomic Absorption Spectrometry. A tag inserted between the element and the measurement unit indicates the element was analyzed by a method other than indicated in the data table name. Analytical methods indicated by tags include ion selective electrode (ISE), LECO (LE), gravimetric (GRAV), and cold vapour atomic absorption (CAA)	75
Ag_ppm	Silver as analyzed by the method indicated in the spreadsheets name. Measurement units are in parts per million	0.068
...	Reporting of concentrations of other analytes follow above methods	...

the samples on a map that highly accurate locations are used. Location information for samples that have been reanalyzed was taken from the original report

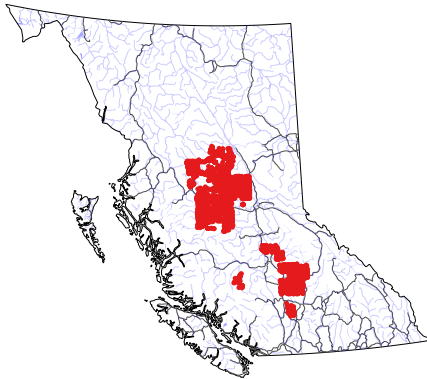
3.3. Analytical methods and reporting

Over the years, analytical techniques have generally improved (e.g., lower detection limits) and preferences for methods used have changed. Most surveys conducted in the province analyzed the silt plus clay (<63 µm) fraction of

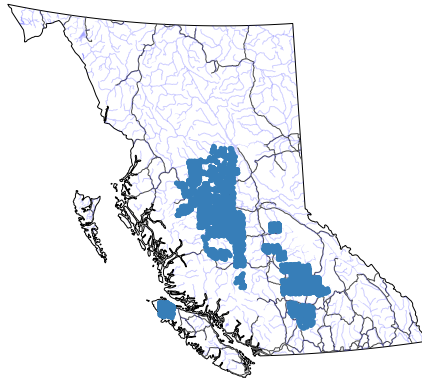
tills, but numerous studies also analyzed the clay (<2 µm) fraction. Analysis of the different size fractions can provide valuable information because different elements may partition in one fraction. For example, chalcophile elements can be concentrated in the clay-size fraction of tills (Nikkarinen et al., 1984; DiLabio, 1995; Shilts, 1984, 1995).

Geochemical surveys in British Columbia use three main analytical techniques (Fig. 4): Inductively Coupled Plasma Emission Spectroscopy (ICP-ES), Inductively Coupled Plasma

ICP Aqua Regia
Clay Fraction (Data Table 1)



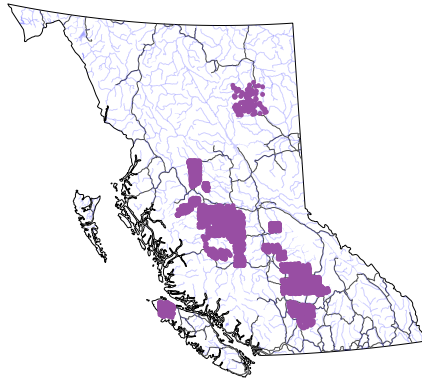
ICP Aqua Regia
Silt+Clay Fraction (Data Table 2)



ICP Fusion
Clay Fraction (Data Table 3)



ICP Fusion
Silt+Clay Fraction (Data Table 4)



INA
Silt+Clay Fraction (Data Table 5)

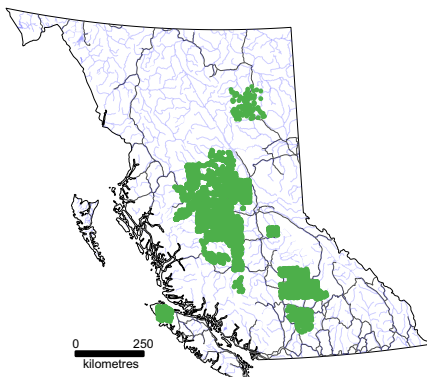


Fig. 3. Locations of analyses included in this data release broken down by Data Table.

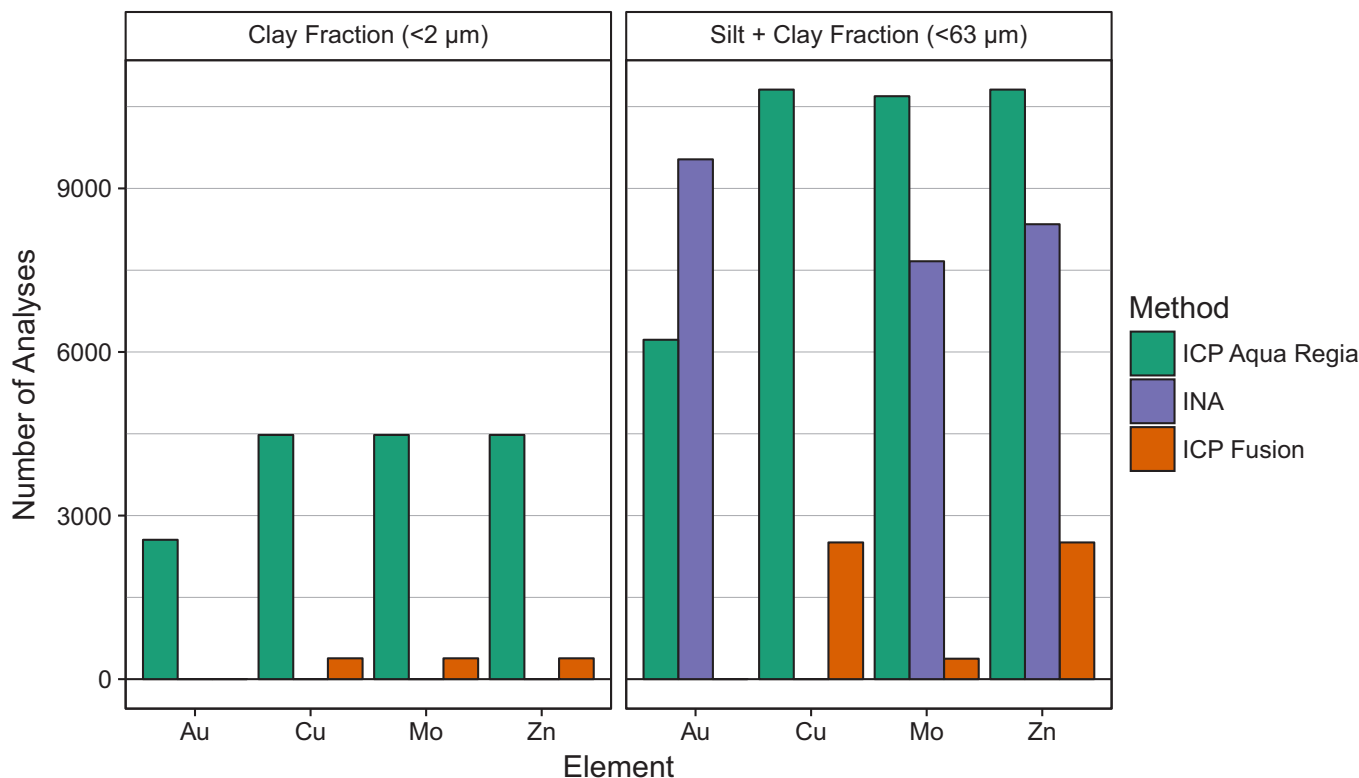


Fig. 4. Summary of the number of analyses performed for common elements by size fraction and analytical technique.

Mass Spectroscopy (ICP-MS), and Instrumental Neutron Activation Analysis (INAA). Analysis by INAA does not require a digestion of the sample, and ICP-ES and ICP-MS typically follow either an aqua regia digestion (“ICP AR” in data table name) or a lithium metaborate/tetraborate fusion (“ICP fusion” in data table name). Other common methods include the analysis of Hg by Cold Vapour Atomic Adsorption or Flameless Atomic Adsorption (AAS), and the analysis of total C and total S using LECO. These methods are indicated by a tag in the column header, and include LECO analysis for C and S (“LE”, included with ICP fusion data), ion selective electrode analysis for F (“ISE”, included with ICP aqua regia data), and cold vapour atomic adsorption for Hg (“AAS”, included with ICP aqua regia data).

Values falling below detection limits are reported as the negative value of the detection limit. Where there was uncertainty if a value was at or less than the detection limit, it was assumed to be less than. Values greater than the upper limit of detection are prefixed with a “>”. In cases of disagreement between the same value across multiple reports, reference was made to the original lab files where possible, and to the original report if lab reports were unavailable. For re-analyzed samples two rows are included in the data tables, with the reanalyzed sample identified in “Sample_Code” column with the suffix “_r”.

4. Conclusion

This data release compiles 25 years of till geochemistry data into a single source. It complements other recent releases of RGS stream sediment, lithogeochemical, and ice-flow indicator data by the BCGS. The data tables included here facilitate the examination of regional-scale till geochemistry in British Columbia, and can assist with the identification of new mineral exploration targets.

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