Mineral Exploration in the Central Interior Copper-Gold Research Projects Area, Central British Columbia (Parts of NTS 093A, B, G, J, K, O): New Tools for a Proven Approach to Exploration Under Cover

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Introduction

Geoscience BC's Central Interior Copper-Gold Research (CICGR) projects area occupies a large region in central British Columbia (BC) between the communities of Mackenzie and Williams Lake (Figure 1a). The region has significant mineral potential, however, exploration is hindered by extensive Quaternary sediments that obscure bedrock. The objective of the CICGR projects is to investigate the potential for undiscovered mineral deposits buried beneath thick glacial sediments.

Drift prospecting is an effective method to identify exploration targets in areas covered by thick glacial sediments and can be optimized when applied within a comprehensive understanding of the glacial history and surficial geology (e.g., Levson et al., 1994; Levson, 2001; Plouffe et al., 2001; Sacco et al., 2018). As such, Geoscience BC has initiated this multiyear surficial exploration program targeting specific areas (surficial study areas; Figure 1a, b) within the larger CICGR projects area. The program is modelled after Geoscience BC's highly successful Targeting Resources through Exploration and Knowledge (TREK; e.g., Jackaman and Sacco, 2014; Jackaman et al., 2014, 2015; Sacco and Jackaman, 2015; Sacco et al., 2018) and Quesnellia Exploration Strategy (QUEST; e.g., Sacco et al., 2010; Ward et al., 2011, 2012, 2013) surficial exploration programs (Figure 1). The CICGR program is generating high-quality baseline data integral to promoting and supporting successful mineral exploration in this challenging setting. Combined with data from the TREK (Jackaman et al., 2015) and QUEST (Ward et al., 2013) projects, the results of this study extend the coverage of directly comparable geochemical and mineralogical data and 1:50 000 scale surficial mapping to a large, nearly continuous portion of central BC (Figure 1c).

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This program is designed to generate a geochemical and mineralogical database and an understanding of the surficial geology necessary to collect and interpret these data, such that they can be integrated into and guide private-sector exploration. The scope of the program defines three objectives:

1) produce 1:50 000 scale surficial geology maps and derive till sampling suitability (TSS) and drift thickness maps to support mineral exploration;
2) compile relevant historical data and reanalyze archived till survey samples; and
3) build upon the historical dataset through new and infill till geochemical and mineralogical surveys.

A summary of the three objectives along with the results from the first two years of the program are presented herein. A more detailed account of these objectives and prior years' activities is available in previous Geoscience BC Summary of Activities publications (Sacco et al., 2020, 2021). The project is currently in its third and final year, during which the focus has largely been on completing the till sampling, field verification and finalization of the surficial geology interpretations, and preparing the survey results for release.

A new program objective was added in 2021 that aims to determine how a hand-portable, shallow-drilling system can be integrated into till sampling programs for regional- to property-scale surveys. The use of a portable, shallow-drilling system to collect till samples is not a new concept. Several groups, including the Geological Survey of Canada (GSC), have tested off-the-shelf products for this purpose (e.g., Plouffe 1995; McMartin and McClenaghan, 2001). Limited success has been realized due to the complex nature of subglacial till; it requires a system that can penetrate overconsolidated sediments containing cobbles and boulders. As a result, industry's only option has been to use larger, more expensive systems, which are not always a feasible option (e.g., reverse circulation or rotosonic systems) to collect till samples in unfavourable conditions. The Talon Drill™ (manufactured by Quantum Machine Works

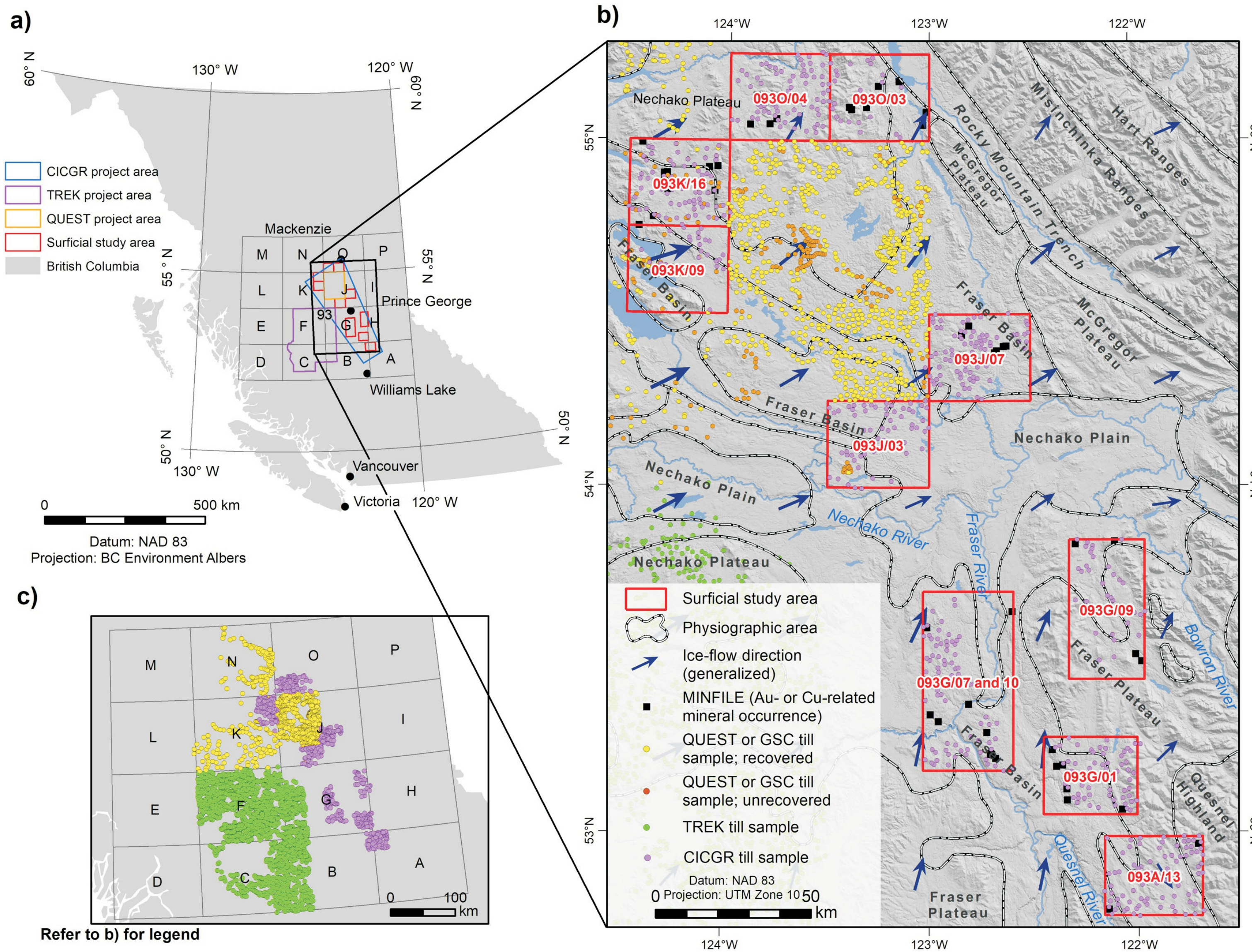

Figure 1. a) Location of Central Interior Copper-Gold Research (CICGR), Targeting Resources through Exploration and Knowledge (TREK) and Quesnellia Exploration Strategy (QUEST) projects areas. **b)** Surficial study areas; physiographic areas (Holland, 1976; Mathews, 1986); MINFILE occurrences (BC Geological Survey, 2020); locations of historical surface sediment samples proposed for reanalysis from QUEST (Ward et al., 2013) and Geological Survey of Canada (GSC) programs (Plouffe and Ballantyne, 1993; Plouffe, 1995; Plouffe and Williams, 1998); TREK till sample locations (Jackaman et al., 2015); and till samples collected during this study. **c)** Distribution of recovered historical till samples (yellow symbols) in central British Columbia, which have been reanalyzed to produce data comparable to existing data from the TREK (green symbols) and current (purple symbols) projects.

Ltd.), modified with custom purpose-built tooling, has proven effective in drilling through subglacial till and has the potential to streamline till sampling programs and improve sampling distribution and coverage, ultimately providing more robust datasets to support explorers in BC.

Project Area and Previous Work

Within the CICGR projects area, the surficial exploration study areas include parts of NTS 093A, B, G, J, K and O and cover approximately 9700 km^2 (Figure 1c). There are 52 MINFILE mineral occurrences related to gold or copper mineralization within the surficial study areas (BC Geological Survey, 2020), although significantly more occur within the larger CICGR projects area. The surficial study areas were determined based on

1) prospective geology,
2) avoidance of private land, and
3) applicability of till sampling.

Some of the study area boundaries are not the same as the NTS map area boundaries to account for these factors. For continuity of the till database, the compilation of historical till data and reanalysis of archived samples extends beyond the CICGR projects area to include the full extent of previous surveys (Figure 1).

The surficial study areas are within the Interior Plateau physiographic region and consist of parts of the Fraser Basin, Fraser Plateau, Nechako Plain, Nechako Plateau, Rocky Mountain Trench and Quesnel Highland (Holland, 1976; Mathews, 1986). Bedrock exposures are commonly obscured by thick surficial deposits, composed dominantly of till, glaciolacustrine and glaciofluvial sediments. Small-scale surficial geology mapping has previously been completed in some parts of the project area, providing an important regional context for the higher resolution interpretations being completed as part of this project. A complete list of regional surficial geology maps that overlap the study areas is available in Sacco et al. (2020).

The regional surficial setting is largely a result of the coalescence and subsequent divergence of glaciers in and around the northern part of the CICGR area during the last (Fraser) glaciation. This dynamic glacial environment resulted in a complex landscape with thick surficial deposits, which have hindered exploration efforts. The coalescence of advancing ice masses caused significant variations in ice flow that affected the depositional patterns of till and altered drainage systems resulting in the development of extensive glacial lakes (Clague, 1988; Plouffe, 1997; Sacco et al., 2017). During deglaciation, ice retreated toward the source areas leaving behind ablating ice masses that again altered drainage resulting in the deposition of large outwash deposits and the development of glacial Lake Fraser: an extensive body of water that changed shape and size throughout deglaciation and in which significant amounts of sediment accumulated. These thick sediment units obscure the underlying bedrock and till, which typically provide a basis for exploration, hindering the collection of high-quality surface data. As a result, the CICGR area is underexplored and its potential mineral resources are largely unknown. Previous till sampling programs have been conducted in the northwestern part of the CICGR area (Figure 1), for which descriptions are provided in Sacco et al. (2020).

In the first two years of this program, the surficial geology, TSS and drift thickness mapping products were drafted. The maps provided the foundation to plan and execute a till sampling program focused mostly in the northern study areas (NTS 093J/03, 07, 093K/09, 16, 093O/03, 04). The historical data were compiled and the archive samples from the GSC and Geoscience BC programs were collected and sent to the lab for reanalysis.

Methods

Objective 1: Surficial Geology Mapping and Derivative Mapping

Surficial geology mapping provides a basis for the collection and interpretation of surface sediment data. The surficial geology was interpreted from pseudo-stereo imagery at a scale of 1:50 000 using the GSC mapping protocols (Deblonde et al., 2018), which maintains consistency with existing regional mapping by the GSC and similar scale mapping by the BC Geological Survey. Specific details of the mapping protocols are provided in Sacco et al. (2020).

Till sampling suitability and drift thickness maps were derived from the surficial geology mapping using multiclass indices to reattribute the polygons. The TSS index was based on the occurrence of subglacial till and geomorphological processes that may have altered, reworked or remobilized the material. This ultimately categorized the polygons based on the proportion of subglacial till at the surface that is suitable for sampling. The drift thickness index used the mapped unit thicknesses and assumed sediment stratigraphy (e.g., glaciolacustrine material is deposited passively, so it is assumed to overlie till) to estimate relative thicknesses for the polygon attributes.

Objective 2: Compilation of Historical Data and Reanalysis of Archive Samples

Reanalyzing till samples archived from previous regional geochemical surveys is a cost-effective method to upgrade the utility of the associated geochemical datasets. Many of these historical projects were completed in the 1990s when sampling protocols were less strict, and a considerable amount of the original results were generated using analytical methods that have been replaced by new procedures that provide more accurate determinations and have lower detection limits. The reanalysis by modern laboratory techniques creates a high-quality dataset that is comprehensive and directly comparable to the standard of current provincial datasets, which support mineral exploration and environmental assessments.

Archive sample material from the silt+clay (<0.063 mm) size fraction was sent to Bureau Veritas Commodities Canada (Bureau Veritas; Vancouver, British Columbia) for analysis to elevate these datasets to current standards. Details of the analytical packages are described in the methods for objective 3 below. Prior to reanalysis, analytical duplicate and control reference samples were inserted into the sample sequence to monitor and assess the accuracy and precision of the new analytical results.

Objective 3: Till Geochemical and Mineralogical Survey

Subglacial till is the target sample media for this survey because it is a first derivative of bedrock (Schilts, 1993), is predictably transported in the direction of ice flow and provides a larger anomaly than the original bedrock source (Levson, 2001). For this program, C-horizon material was collected to reduce the influence of soil development and postdepositional processes on the geochemical concentrations of the material. As such, anomalies can be more confidently attributed to geology (i.e., mineralization) as opposed to other processes that cause spurious results in A- or B-horizon soil data. The surficial geology and TSS mapping provided the foundation to plan and collect suitable subglacial till samples at ~2 km spacing. The survey was conducted to established standards, producing high-quality field and analytical results that are consistent with, and comparable to, the existing provincial till geochemical database.

The till geochemical and mineralogical survey was completed during years two and three of the program. Most of the sampling relied on existing exposures of sediments (e.g., roadcuts), termed 'opportunistic exposures', which were targeted to reach the in situ, C-horizon subglacial till. To sample these exposures, it was necessary that the till be at or close to the surface and the site be accessible via an active road. In many areas, there are sufficient opportunistic exposures to achieve the desired sample distribution for a regional program, but in some areas this can be challenging due to a lack of optimal sampling sites. This year, a new method of sampling using a shallow-drilling system was introduced to access C-horizon till without being constrained by the occurrence of opportunistic exposures, while also providing a means to collect samples beneath veneers of other materials.

At opportunistic sites, the standard protocol was used. This involved collecting two, ~1 kg, C-horizon subglacial till samples for geochemical analysis and 50 clasts (ranging in size from large pebble to small cobble) for lithological analysis. At approximately every other site (i.e., half density), an additional 10–12 kg sample was collected for mineralogical analysis. Sacco et al. (2020) provides additional details for the field sampling and data collection protocols used at opportunistic sampling sites.

The drill-supported sampling was completed with the Talon Drill tooled with custom bits and samplers specifically designed and engineered for till sampling (Figure 2).

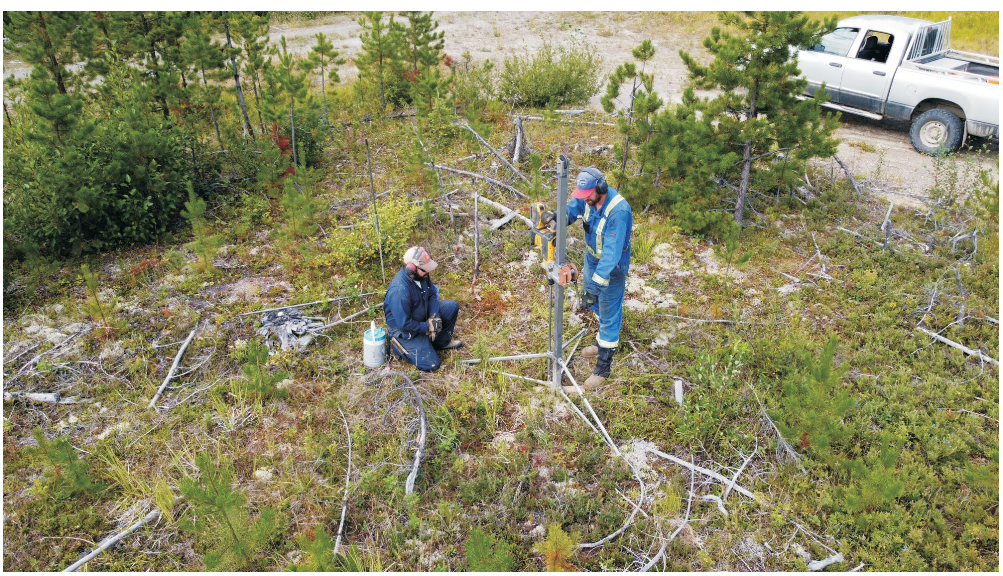

Figure 2. The Talon Drill™ system tooled with custom bits and samplers specifically designed to work within the difficult drilling conditions encountered when sampling subglacial till. This system enables the collection of high-quality till samples anywhere the till occurs at or near the surface. This method of till sampling overcomes the limitations of standard opportunistic sampling programs, which can result in suboptimal sample distributions because of the reliance on sampling existing exposures.

It is a rotary-percussion system designed to displace fine-grained material (i.e., till matrix) while the specialized bits and hammer-action are capable of pulverizing clasts and drilling through boulders that may be encountered. This system provides a nearly zero-impact method to quickly and easily access C-horizon till at surface or buried beneath a shallow deposit of other materials, which would have otherwise been inaccessible. At a typical drill-sample site, a series of pilot bits were used to penetrate to a suitable sample depth of ~1.5 m. A specialized sampler was then attached to collect an in situ sample from the bottom of the hole. Approximately 500 g of till matrix was collected at each sample site for geochemical analysis. Due to the smaller sample sizes and limited exposure of in situ material compared to the opportunistic sites, the single 500 g sample was used for all analyses and no pebble or mineralogy samples were collected.

Geochemical analysis for all samples is being performed by Bureau Veritas. The samples are dried and processed to produce clay (<0.002 mm) and silt+clay (<0.063 mm) size fraction splits. Both size fractions will be analyzed for minor and trace elements by an ultratrace, aqua-regia digestion (0.5 g sample), inductively coupled plasma–mass spectrometry (ICP-MS) package for 53 elements and by instrumental neutron activation analysis (INAA) for total gold plus 34 elements. Major and minor elements will be determined by inductively coupled plasma–emission spectrometry (ICP-ES) following a lithium metaborate-tetraborate fusion and dilute acid digestion. This analytical package will include loss-on-ignition by weight difference after ignition at 1000ºC, plus total carbon and sulphur by LECO analysis. The LECO analysis converts carbon and sulphur forms in a sample into CO_2 and SO_2 by combustion in an induction furnace. The concentrations of CO_2 and SO_2 are measured by infrared absorption and thermal conductivity to determine total concentrations of carbon and sulphur. Quality control for analytical determinations will include the use of field duplicates, analytical duplicates, reference standards and blanks, based on established protocols (Spirito et al., 2011).

Clast lithologies were grouped into broad categories that reflect the main lithologies of local bedrock to provide insight on the direction and distance of glacial transport. The bulk till samples were sent to Overburden Drilling Management Limited (Ottawa, Ontario) and processed for gold grain concentrates (<2.0 mm) and heavy and medium mineral concentrates (0.25–2.0 mm) using a combination of gravity tables and heavy liquids. Concentrates will be visually picked for gold and porphyry-copper–indicator minerals.

Progress and Future Work

The surficial geology interpretations provided the foundation to develop the CICGR surficial exploration field program strategy. Draft surficial geology, TSS and drift thickness mapping was completed in year one and revealed that TSS is most heavily influenced by the distribution of glacial lake sediments and ablation till. These deposits are also generally associated with thicker drift as they tend to accumulate in large depressions (i.e., lowlands around Prince George) and within valley fill sequences. The surficial geology interpretations and derivative products have been refined and finalized based on field observations for 093J/03, 07, 093K/09, 16, 093O/03 and 04. These map products were released as Geoscience BC Report 2021-03 (Palmer, 2021), which is a compilation of 18 georeferenced PDF maps. The field observations collected for the study areas associated with 093A/13, 093G/01, 07, 09 and 10 are currently being compiled and used to finalize the respective mapping products. The release of the remaining surficial map sets is planned for early 2022. The release will include georeferenced PDF map sets of surficial geology, TSS and drift thickness, and spatial data for the complete map series, including the already released map sets.

A total of 1039 archive samples or pulps (i.e., representative 2 g splits of the silt+clay [<0.063 mm] size fraction) were recovered for reanalysis. Six hundred and seventy-two of these were archive samples originally collected in the late 2000s as part of Geoscience BC's QUEST project (Ward et al., 2013). Three hundred and sixty-seven were pulps retained from regional till surveys completed by the GSC in the 1990s (Plouffe and Ballantyne, 1993; Plouffe, 1995; Plouffe and Williams, 1998). Approximately 330 pulps and 153 archive till samples could not be located. The reanalysis has been completed and the results have been released in Geoscience BC Report 2021-09 (Jackaman et al., 2021).

The 2020 and 2021 till sampling programs were complicated by the COVID-19 pandemic. Field crews adhered to WorkSafeBC guidelines with a focus on the maintenance of working-group bubbles to reduce the risk of crew exposure and community spread of COVID-19. Lodging and travel options were restricted, resulting in longer daily commutes to the study areas and driving rather than flying to field sites. Although these complications had an impact on daily productivity, the goals of completing the till sampling program throughout all map areas and verifying the mapping with field-based information were achieved.

Six hundred and thirty-four new till samples were collected in the survey area. The expected sample density has been achieved throughout most of the individual study areas; however, some regions are lacking adequate coverage (Figure 1c). The main factors inhibiting till sample collection were a lack of road access, limited opportunistic sampling sites and/or materials of another genesis overlying the till and impeding sampling. Few till samples were collected from the eastern portion of 093O/03 due to the extensive outwash deposits and a lack of road access. Sample coverage in much of 093K/09 is poor due to extensive mantles of thin glaciolacustrine material that cover the till, and low relief that results in few roadcuts. Similarly, sample coverage in 093G/07 and 10 is limited due to the extensive glaciolacustrine mantles overlying the till, particularly in the Fraser River Valley where till has largely been eroded or buried through glaciofluvial activity. The desired sample density was also not achieved on the east side of 093J/07 and throughout 093G/09. Deglacial sediments impeded access to till in both map areas, but a lack of road access was the biggest issue in 093G/09.

Testing of the Talon Drill system was focused mainly on the northern part of 093J/03. This area was chosen because road access is relatively good, opportunistic exposures are rare and till generally occurs either at surface or buried under a thin veneer of glaciolacustrine material throughout much of the area. This area provided optimal testing conditions for the drill system because of the combination of factors that hindered standard opportunistic sampling here.

In 2020, 29 opportunistic samples were collected in 093J/03 and the map area was considered finished because no other existing exposures could be located for sampling. In 2021, 31 additional samples were collected using the shallow-drilling system, doubling the sample density for the map area and greatly improving the coverage and distribution of sampling (Figure 3). Average sampling times were about 90 minutes, including the set up and tear down of the drill. This average time would likely be lower during a production-focused program because additional time was spent at some sites testing different tooling and some suboptimal sites were chosen in order to determine how the drill would perform. Nevertheless, drill-supported sampling rates averaged only 0.3 samples per day lower than the standard opportunistic approach with hand tools, and the resulting sample distribution and coverage were significantly better, demonstrating the efficacy and value of the system.

Many of the drill-supported samples were collected in areas where till was predicted to occur but existing exposures were lacking to verify the surficial material type. Due to

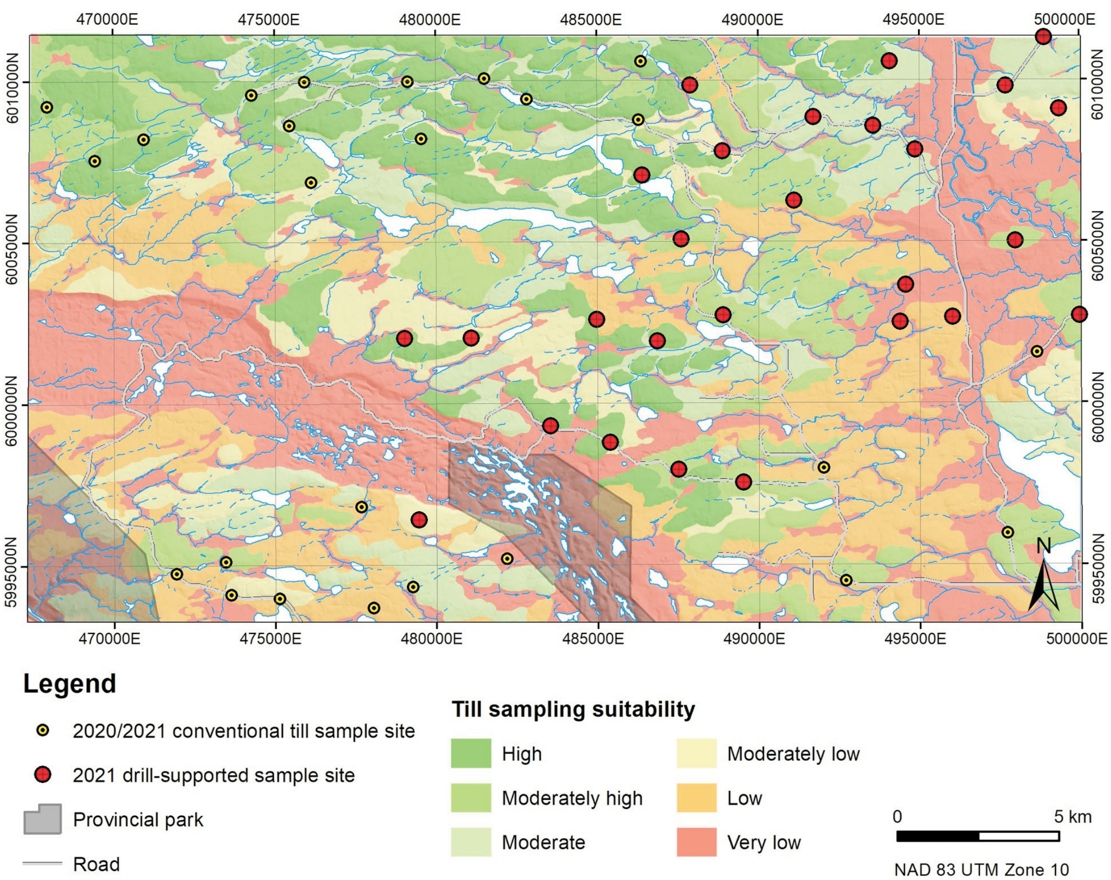

Figure 3. Sample distribution attained using the standard ‘opportunistic’ method of till sampling (yellow symbols) with hand tools from existing sediment exposures, such as roadcuts, and using the Talon Drill™ shallow-drilling system (red symbols) in the northern part of NTS map area 093J/03. Till sampling suitability classifications are defined in Sacco et al. (2020).

this lack of exposures, knowledge that till is present at the sample sites was integral to success, which was largely accomplished through the examination of shallow test pits and the experience of the sampling crew. The 1:50 000 scale mapping completed for this program provides an understanding of the general setting but lacks the detail to determine the conditions at a specific site. In the absence of higher resolution mapping, the ability of sampling crews to interpret the landscape will be critical in future programs that employ drill-supported sampling.

The drilling system was tested to determine how much of the till profile can be effectively sampled and the maximum thickness of overlying materials below which samples can be collected. In general, the first metre of till requires less than 10 minutes to drill through, whereas the second metre requires an additional 15 minutes. The third and the fourth metres require about 25 and 40 minutes, respectively. The maximum depth reached in till was 3.9 m. Further depths could be reached, but it was decided that enough information had been gained and the time was better spent sampling other sites. Reaching a depth of 4 m in about 90 minutes is impressive, but the decreased drilling rate with depth makes drilling deeper counterproductive for a regional program. For target-scale work, the value of the data would necessitate the extra time, but in general an ~2 m depth is considered optimal for a regional survey.

The clast content of the till was the largest factor contributing to drilling rates. The drill advanced through most clasts that were encountered in the till. Pebble- to medium cobble-sized (2–15 cm) clasts were quickly surpassed, although rounded quartzite pebbles and cobbles posed a challenge as the hardness and rounding caused the bit to move laterally, binding the rod string against the hole. Clasts can usually be penetrated to about 10 cm within five minutes, at which time they will typically fracture and displace. If the clast has not been surpassed within five minutes, it could be too large to advance through in a reasonable amount of time. In these cases, it was determined to be more efficient to move the drill a metre or two and start a new hole. There is no way of predicting how large the clast is and it is likely faster to drill through a new section of till than risk spending too much time slowly advancing through a boulder.

The drill advanced through softer sediments considerably faster than through till. At numerous locations, 1 to 2.5 m of glaciolacustrine sand and silt were smoothly advanced through in 5 to 30 minutes. When suitable till was encountered, which is demarcated by an obvious change in drilling rates, samples could be collected immediately below the fine-grained material. In general, fine-grained glaciolacustrine materials were not a hindrance to sampling; however, accurately predicting their depth when thicker than a few metres can be difficult. As such, it is recommended to only attempt sampling beneath areas interpreted as having thin mantles (e.g., <2 m) of glaciolacustrine sediment, to avoid the potential of beginning a hole that would require more time than anticipated and lowering production rates. Nonetheless, the results of this testing indicate that the Talon Drill system provides a means to extend till sampling into areas that are mapped as glaciolacustrine veneer overlying till, which were previously identified as poorly suited for sampling.

In 2021, 38 samples were collected using the Talon Drill and 140 samples were collected from roadcut exposures. These samples have been sent to Bureau Veritas and Overburden Drilling Management Ltd. for geochemical and mineralogical analyses, respectively. The geochemical, mineralogical and pebble data from the new samples will be evaluated and compiled before they are released as digital databases, which will include all analytical results and quality control data. The data are expected to be ready for release in mid 2022.

Conclusions

The Central Interior Copper-Gold Research (CICGR) surficial exploration program has produced over 9700 km^2 of new surficial geology, till sampling suitability and drift thickness mapping to support mineral exploration. Using these products, 634 new subglacial till samples were collected that infill gaps within the existing historical datasets and extend coverage into new areas. From the archives, 1039 samples were reanalyzed. The project results, combined with data from the earlier Targeting Resources through Exploration and Knowledge (TREK) and Quesnellia Exploration Strategy (QUEST) projects, extend the coverage of comprehensive geochemical and mineralogical data to a nearly continuous portion of central British Columbia, and will promote increased awareness in a highly prospective region, assist in the identification of new exploration targets and support follow-up activities.

The data-driven approach to this program contributes heavily to its success. A foundational understanding of the surficial geology not only informs the design and execution of the program, but also identifies the characteristics of the areas that are not suitable for the standard sampling methodologies. Low relief, resulting in a lack of opportunistic exposures, and mantles of deglacial materials overlying the till are recurring challenges to achieving optimal sample distributions. A new method of sampling using a hand-portable, ultra-lightweight drill was tested this year to overcome these challenges. The testing revealed that the Talon Drill™, tooled with customized bits and samplers, effectively extended sample coverage into areas where standard opportunistic sampling methods were not successful. These results suggest that the use of this method can be extended to the east part of NTS 093O/03, the majority of 093K/09, southeast corner of 093J/07 and much of 093G/07 and 10 to improve data coverage in those regions, and the overall success of the CICGR surficial exploration program.

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References

BC Geological Survey (2020): MINFILE BC mineral deposits database; BC Ministry of Energy, Mines and Low Carbon Innovation, BC Geological Survey, URL <http://minfile.ca/> [October 2020].

Clague, J.J. (1988): Quaternary stratigraphy and history, Quesnel, British Columbia; Géographie physique et Quaternaire, v. 42, p. 279–288.

Deblonde, C., Cocking, R.B., Kerr, D.E., Campbell, J.E., Eagles, S., Everett, D., Huntley, D.H., Inglis, E., Parent, M., Plouffe, A., Robertson, L., Smith, I.R. and Weatherston, A. (2018): Surficial data model: the science language of the integrated Geological Survey of Canada data model for surficial geology maps (ed. ver. 2.3.14); Geological Survey of Canada, Open File 8236, 50 p.

Holland, S.S. (1976): Landforms of British Columbia: a physiographic outline (second edition); BC Ministry of Energy, Mines and Low Carbon Innovation, Bulletin 48, 138 p.

Jackaman, W. and Sacco, D. (2014): Geochemical and mineralogical data, TREK project, Interior Plateau, British Columbia; Geoscience BC, Report 2014-10, 13 p., URL <http://www.geosciencebc.com/reports/gbcr-2014-10/> [October 2020].

Jackaman, W., Sacco, D. and Lett, R.E. (2014): Geochemical reanalysis of archived till samples, TREK project, Interior Plateau, central BC (parts of NTS 093C, 093B, 093F & 093K); Geoscience BC, Report 2015-09, 5 p., URL <http://www.geosciencebc.com/reports/gbcr-2015-09/> [October 2020].

Jackaman, W., Sacco, D.A. and Lett, R.E. (2015): Regional geochemical and mineralogical data, TREK project – year 2, Interior Plateau, British Columbia; Geoscience BC, Report 2015-12, 13 p., URL <http://www.geosciencebc.com/reports/gbcr-2015-12/> [October 2020].

Jackaman, W., Sacco, D.A. and Lett, R.E. (2021): Geochemical reanalysis of archived till samples, CICGR surficial exploration project, Interior Plateau, north central BC (parts of NTS 093A, B, G, J, K, O); Geoscience BC, Report 2021-09, 13 p., URL <http://geosciencebc.com/i/project_data/GBCReport2021-09/GBC%20Report%202021-09%20Geochemical%20Reanalysis%20of%20Archived%20Till%20Samples%20Report%20and%20Data.zip> [October 2021].

Levson, V.M. (2001): Regional till geochemical surveys in the Canadian Cordillera: sample media, methods, and anomaly evaluation; *in* Drift Exploration in Glaciated Terrain, M.B. McClenaghan, P.T. Bobrowsky, G.E.M. Hall and S.J. Cook (ed.), Geological Society, Special Publication No. 185, p. 45–68.

Levson, V.M., Giles, T.R., Cook, S.J. and Jackaman, W. (1994): Till geochemistry of the Fawnie Creek area (93F/03); BC Ministry of Energy, Mines and Low Carbon Innovation, BC Geological Survey, Open File 1994-18, 40 p., URL <https://www2.gov.bc.ca/gov/content/industry/mineral-exploration-mining/british-columbia-geological-survey/publications/openfiles-1999-1990#1994> [October 2020].

Mathews, W.H. (1986): Physiographic map of the Canadian Cordillera; Geological Survey of Canada, “A” Series Map 1710A, scale 1:5 000 000.

McMartin, I. and McClenaghan, B. (2001): Till geochemistry and sampling techniques in glaciated shield terrain: a review; *in* Drift Exploration in Glaciated Terrain, M.B. McClenaghan, P.T. Bobrowsky, G.E.M. Hall and S.J. Cook (ed.), Geological Society, Special Publication No. 185, p. 19–43.

Palmer (2021): Surficial geology, drift thickness and till sampling suitability maps (NTS 093J/03, 07; 093K/09, 16; 093O/03, 04), British Columbia; Geoscience BC, Report 2021-03, 18 maps, scale 1:50 000, URL <http://geosciencebc.com/i/project_data/GBCReport2021-03/GBC%20Report%202021-03%20Surficial%20Geology,%20Drift%20Thickness%20and%20Till%20Sampling%20Suitability%20Maps.zip> [October 2021].

Plouffe, A. (1995): Geochemistry, lithology, mineralogy and visible gold grain content of till in the Manson River and Fort Fraser map areas, central British Columbia (NTS 093K, N); Geological Survey of Canada, Open File 3194, 119 p.

Plouffe, A. (1997): Ice-flow and late-glacial lakes of the Fraser glaciation, central British Columbia; *in* Current Research 1997-A/B, Geological Survey of Canada, p. 133–143.

Plouffe, A. and Ballantyne, S.B. (1993): Regional till geochemistry, Manson River and Fort Fraser area, British Columbia (NTS 093K, N), silt plus clay and clay size fractions; Geological Survey of Canada, Open File 2593, 224 p.

Plouffe, A. and Williams, S.P. (1998): Regional till geochemistry of the northern sector of Nechako River map area, British Columbia (NTS 093F); Geological Survey of Canada, Open File 3687, scale 1:400 000.

Plouffe, A., Levson, V.M. and Mate, D.J. (2001): Till geochemistry of the Nechako River map area (NTS 93F), central British Columbia; Geological Survey of Canada, Open File 4166, 66 p.

Sacco, D.A. and Jackaman, W. (2015): Targeted geochemical and mineralogical surveys in the TREK project area, central British Columbia (parts of NTS 093B, C, F, G): year two; *in* Geoscience BC Summary of Activities 2014, Geoscience BC, Report 2015-01, p. 1–12, URL <http://cdn.geosciencebc.com/pdf/SummaryofActivities2014/SoA2014_Sacco.pdf> [October 2020].

Sacco, D.A., Jackaman, W. and Knox, C. (2021): Proven approach to mineral exploration in thick surficial deposits applied to the Central Interior Copper-Gold Research projects area, central British Columbia (parts of NTS 093A, B, G, J, K, O); *in* Geoscience BC Summary of Activities 2020: Minerals, Geoscience BC, Report 2021-01, p. 1–10, URL <http://

www.geosciencebc.com/i/pdf/SummaryofActivities2020/Minerals/Project%202018-050_MineralsSOA2020.pdf> [October 2021].

Sacco, D.A., Jackaman, W. and McGregor, C. (2020): Mineral exploration in central British Columbia's thick surficial deposits: surficial mapping to inform surface sediment data compilation and till sample reanalysis and collection in the Central Interior Copper-Gold Research project area (parts of NTS 093A, B, G, J, K, O); *in* Geoscience BC Summary of Activities 2019: Minerals, Geoscience BC, Report 2020-01, p. 83–92, URL <http://www.geosciencebc.com/i/pdf/SummaryofActivities2019/Minerals/Project%202018-050_Minerals_SOA2019.pdf> [October 2020].

Sacco, D.A., Lett, R., Jackaman, W. and Elder, B. (2018): Advanced processing of the TREK project geochemical data: identifying and enhancing geochemical anomalies in the TREK project area using sediment transport modeling combined with multimedia and multivariate analysis; Geoscience BC, Report 2018-07, 56 p., URL <http://www.geosciencebc.com/i/project_data/GBCReport2018-07/GBCReport2018-07.pdf> [October 2020].

Sacco, D.A., Ward, B.C., Lian, O.B., Maynard, D.E. and Geertsema, M. (2017): Quaternary geology of part of the McLeod Lake map area (NTS 093J), central British Columbia: lithostratigraphy, glacial history, and chronology; Canadian Journal of Earth Sciences, v. 54, no. 10, p. 1063–1084.

Sacco, D.A., Ward, B.C., Maynard, D., Geertsema, M. and Reichheld, S. (2010): Terrain mapping, glacial history and drift prospecting in the northwest corner of McLeod Lake map area (part of NTS 093J), central British Columbia; *in* Geoscience BC Summary of Activities 2009, Geoscience BC, Report 2010-01, p. 33–42, URL <http://cdn.geosciencebc.com/pdf/SummaryofActivities2009/SoA2009_Sacco.pdf> [October 2020].

Shilts, W. (1993): Geological Survey of Canada's contributions to understanding the composition of glacial sediments; Canadian Journal of Earth Sciences, v. 30, p. 333–353.

Spirito, W.A., McClenaghan, M.B., Plouffe, A., McMartin, I., Campbell, J.E., Paulen, R.C. and Hall, G.E.M. (2011): Till sampling and analytical protocols for GEM projects: from field to archive; Geological Survey of Canada, Open File 6850, 83 p.

Ward, B.C., Leybourne, M.I. and Sacco, D.A. (2011): Drift prospecting within the QUEST project area, central British Columbia (NTS 093J): potential for porphyry copper-gold, volcanogenic massive sulphide mineralization and gold-copper veins; *in* Geoscience BC Summary of Activities 2010, Geoscience BC, Report 2011-01, p. 73–96, URL <http://cdn.geosciencebc.com/pdf/SummaryofActivities2010/SoA2010_Ward_etal.pdf> [October 2020].

Ward, B.C., Leybourne, M.I. and Sacco, D.A. (2012): Heavy mineral analysis of till samples within the QUEST project area, central British Columbia (NTS 093J); *in* Geoscience BC Summary of Activities 2011, Geoscience BC, Report 2012-01, p. 59–68, URL <http://cdn.geosciencebc.com/pdf/SummaryofActivities2011/SoA2011_Ward.pdf> [October 2020].

Ward, B.C., Leybourne, M.I., Sacco, D.A., Lett, R.E. and Struik, L.C. (2013): Drift prospecting for porphyry copper-gold, volcanogenic massive sulphide mineralization and precious and base metal veins within the QUEST project area, central British Columbia (NTS 093J); Geoscience BC, Report 2013-15, 59 p., URL <http://www.geosciencebc.com/reports/gbcr-2013-15/> [October 2020].